



# RAPTOR RESEARCH

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The Raptor Research Foundation, Inc.  
Provo, Utah

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## TOWARD RAPTOR COMMUNITY ECOLOGY: BEHAVIOR BASES OF ASSEMBLAGE STRUCTURE

FABIAN M. JAKSIC

**ABSTRACT** — Despite definite advantages in comparison to other model systems (e.g. assemblages of passerine birds and lizards), raptor community ecology is in its infancy. I discuss the adequacy of raptors as model predators for the study of the relationships between behavioral processes (agonistic interactions and hunting modes) and assemblage-level patterns (community structure).

Community ecology studies of animals can be equated with the identification and quantification of the niche axes along which sympatric species appear to separate in order to reduce co-use of resources in limited supply. Schoener (1974) identified habitat, food, and time as the axes that most frequently separate vertebrate predators (including arthropod consumers such as passerine birds and lizards, as well as carnivorous vertebrates). Indeed, the study of insectivorous passerine birds as model predators has contributed substantially to the development of community ecology, as attested by the pioneering studies of MacArthur (1972) and Cody (1974; Cody and Diamond 1975); (see Strong et al. 1984 for more recent views). Subsequently, lizards have gained considerable importance as model predators (see Huey et al. 1983 for an overview of past and current contributions of herpetologists to community ecology).

The early findings of Schoener (*op. cit.*), although disputed by some in terms of the underlying causes (see Strong et al. (*op. cit.*) for a confrontation of views), have by and large been held as verified. Both with passerine birds and lizards it has been shown that species often segregate along habitat (or microhabitat) dimensions. However, the data demonstrating food segregation among these organisms are suspect for reasons described below, and the adequacy of activity time as a niche difference is under serious questioning (e.g., Jaksic 1982; Huey and Pianka 1983, Carothers and Jaksic 1984). Adding to the confusion is the fact that the three niche axes are usually correlated (segregation along one of them leads to segregation along another),

thus making causality difficult to resolve. The reasons for these correlations are easy to infer. For example, the trophic structure (patterns of prey use) of sympatric assemblages, which is described on the basis of the diets of the component predators (taxonomic composition, diversity, interspecific similarity, mean prey size, etc.) is only the outcome of behavioral processes occurring at the level of the local population. These processes involve not only prey selection, but also habitat preferences by the individual predators, their activity times, foraging modes and efficiencies, as well as morphological, physiological, and ecological constraints.

The gap between the summary description of food-niche patterns in predator assemblages and the foraging mode of individual predator species has recently been bridged for passerine birds (Eckhardt 1979; Robinson and Holmes 1982) and lizards (Huey and Pianka 1981). In my view, however, these two groups of organisms, which seem to be very suitable for studies of habitat preferences and microhabitat partitioning, are less suitable for the study of prey selection and food segregation. First, prey in their diet often are identifiable only to the ordinal level, and with some difficulty (at least for ornithologists) to the familial level, which represents an important shortcoming. Greene and Jaksic (1983) have shown that in dietary studies of predators identification of prey at the ordinal level (customarily used in passerine and lizard diet studies) underestimates diet diversity and overestimates diet similarity calculated at the species level of prey identification. Further, Greene and Jaksic (*op. cit.*) have shown that these biases arise in unpre-



dictable fashion, so that no reliable correction factors can be introduced in the computation of dietary statistics and consequently the food-niche patterns so far documented for passerine birds and lizards are suspect.

A second shortcoming of using passerine birds and lizards as model predators is that they are subject to predation themselves. This renders it difficult to resolve whether they maximize some prey selection function or compromise the use of optimal prey by minimizing predation risks (an important consideration in terms of optimal foraging theory: see Pyke et al. 1977).

These two shortcomings become especially apparent if one's intention is to correlate food-niche statistics (for whole predator assemblages) with the foraging modes of the constituent species. It is unfortunate that this is so, because I think that the question of how foraging mode is reflected in the trophic structure of sympatric predators is an important one in community ecology. Provided that neither passerine birds nor lizards seem particularly adequate model predators for such an enquiry, I contend that raptors (Order Falconiformes and Strigiformes) may help clarify the relationships between "basal" behavioral processes and "epiphenomenic" patterns of assemblage structure. In the following sections I discuss the pros and cons of using raptor assemblages as models for behaviorally-based community analyses and propose the type of information to be gathered.

#### RAPTOR ASSEMBLAGES AS MODEL SYSTEMS

Until recently, raptors have been neglected as model predators in community ecology. Nevertheless they have much to offer toward the clarification of niche relationships among sympatric consumers. Segregation of raptors along the habitat axis has been documented both intra- and interspecifically (e.g., Newton 1979; Schmutz et al. 1980; Nilsson et al. 1982; Janes 1984), but this segregation does not clearly result in access to different prey populations. Consequently, reduction of exploitative competition seems an unlikely cause for such phenomenon, nor does use of the same hunting habitat lead to compensatory differentiation along the food axis (Schnell 1968; Baker and Brooks 1981; Steenhof and Kochert 1985) which may be interpreted as resulting from the functional response of essentially opportunistic raptors to high prey densities (Jaksic et al. 1981; Jaksic and Braker

1983; Erlinge et al. 1984). In my impression, where habitat separation is observed among raptors, the proximate cause lies on agonistic interactions — a claim for which both direct (Rudolph 1978; Janes *op. cit.*) and indirect evidence exists (see Newton 1979; Jaksic 1982; Mikkola 1983, for summaries of predation among raptors, an extreme form of agonistic interaction). Consequently, the use of exclusive ranges by raptors relate to reduction of interference rather than of exploitative competition.

Something similar may be said of the causes of temporal segregation. Jaksic (1982) documented that diurnal and nocturnal raptors do not differ enough in prey use (i.e., their diets are too similar) to justify the view that they reduce exploitative competition by differing in activity period (similar conclusions were reached by Huey and Pianka 1983). In fact, Jaksic (*op. cit.*), based on circumstantial evidence, contended that reduction of agonistic interactions was the likely target of such temporal segregation of activity. Carothers and Jaksic (*op. cit.*), have elaborated this point on more theoretical grounds, and for a variety of other organisms. Rudolph (*op. cit.*) documented temporal segregation between two sympatric owl species, mediated by predation of one upon the other. Notice, then, that where interspecific segregation of raptors along habitat and time dimensions has been reported, the proximate factor may well be aggressive exclusion rather than peaceful preemption of specific resources as accomplished by differential efficiencies in the exploitation of portions of the niche axes. The latter has been the general assumption underlying most studies of community ecology, and I think that the study of raptor assemblages can contribute greatly to the understanding of the alternative mechanism (interference competition) in generating the structure of communities.

What about food partitioning? Studies ranging in generality from selected pairs of species through small groups of related raptors to entire assemblages have rendered varied conclusions (e.g., Schmutz et al. (*op. cit.*); Jaksic and Braker (*op. cit.*); Knight and Jackman 1984; Marks and Marti 1984). Results indicate that sometimes prey is partitioned via size differences between raptors (accipiters are good examples of this: see Storer 1966; Opdam 1975; Schoener 1984), and that sometimes raptors differing greatly in body size take essentially the

same prey (Schmutz et al. (*op. cit.*); Jaksic 1983; Jaksic and Braker (*op. cit.*)). There is a tendency, though, for particular raptor groups to "specialize" on certain general prey categories (e.g., kites and harriers on small mammals and birds, small falcons on insects, larger falcons on medium-sized mammals and birds, eagles on hares; buteonines appear very catholic in diet). These different groups of raptors share in common similar morphologies and hunting modes (*see* Jaksic and Carothers 1985), which leads me to suggest that the reported trophic structure of the few raptor assemblages so far quantified (*see* Jaksic 1982, 1983; and Jaksic and Braker (*op. cit.*)) somehow reflects those similarities. I do not exactly share the view of Ricklefs and associates (e.g., Ricklefs and Cox 1977; Bierregaard 1978; Ricklefs and Travis 1980) that it is not necessary to go to the field for studying community ecology: morphologic analyses suffice. Instead, I espouse the view (*see also* Steenhof and Kochert (*op. cit.*)) that the study of the hunting behavior of raptors will tell us much about the way assemblages are structured. That is, how behavioral processes result in community patterns.

In comparison to both passerine birds and lizards, the scrutiny of raptor food-niche relationships is facilitated by their greater conspicuousness and use of prominent roosting and nesting sites, where detailed information on their diet can be obtained. However, they also show some shortcomings as model predators. Despite the fact of generally being top predators in terrestrial ecosystems, raptors are not entirely free of predation. Some species are indeed frequently preyed upon by other raptors (*see* Newton *op. cit.*; Mikkola *op. cit.* for summaries), and thus the study of raptor assemblages does not completely eliminate the dual constraints of energy maximization and mortality minimization. But at least in comparison to passerine birds and lizards, raptor behavior should, on the average, be less affected by predation.

The problem of the taxonomic resolution of prey (Greene and Jaksic (*op. cit.*)) is important in raptors that prey primarily on insects; but essentially carnivorous raptors abound, and their vertebrate prey is easily identifiable to the species level, particularly if mammalian (*see* Errington 1930; Burton 1973, for examples). In comparison to passerine birds and lizards, then, accurate estimates can be made of raptor diet diversity (= breadth) and interspecific similarity (= overlap). In addition, open-terrain

raptors are relatively large, conspicuous birds whose time budget, hunting mode, and hunting success, can be quantified with minimal equipment (*see* Rudebeck 1950, 1951; Warner and Rudd 1975; Tarboton 1978; Wakeley 1978a, 1978b; Mendelsohn 1982; Rudolph 1982). Consequently, the proportional use that raptors make of differing hunting modes can be recorded and examined in light of their diets and hunting success in different habitat types. In sum, at least as compared to passerine birds and lizards, raptor assemblages are excellent candidates for the study of food-niche relationships of sympatric predators as related to the hunting behavior of the component species. In the following section I propose the type of information to be gathered for such an aim.

#### INFORMATION REQUIRED TO ASSESS COMMUNITY-ECOLOGICAL CORRELATES OF RAPTOR HUNTING BEHAVIOR

**1. The use that sympatric raptors make of different hunting techniques.** — Raptor hunting activities can be dichotomized as either perch- or aerial-hunting. Within this second category, at least four techniques can be recognized: a) hovering flight: a stationary flight that may or may not take advantage of the wind conditions; used by small falcons (e.g., *Falco sparverius*), small kites (e.g., *Elanus* spp.), and by the Burrowing Owl (*Athene cunicularia*); b) cruising flight: a high-speed, low-altitude flight; used by large falcons (e.g., *Falco mexicanus*) and accipiters (*Accipiter* spp.); c) quartering flight: a low-speed, to-and-fro flight; used by harriers (*Circus* spp.), and some owls (*Asio flammeus*, *Tyto alba*); and d) soaring flight: low-speed, high-altitude flight that takes advantage of either thermal or obstruction air currents; used by eagles (e.g., *Aquila* spp.) and buteonine hawks (*Buteo* spp.), among others. More detailed descriptions of these hunting flight techniques can be seen in Brown and Amadon (1968), Warner and Rudd (1975), Everett (1977), Tarboton (1978), Wakeley (1978b), Cade (1982), Rudolph (1982), Collopy (1983a), and Collopy and Koplin (1983). Recognition of these five techniques seems necessary because there are indications that they facilitate access to different habitats and prey types, and also because their energetic costs differ (*see* Jaksic and Carothers 1985 for a selective summary). The time allocated to the different hunting techniques by sympatric raptors should be evaluated and, noting the prey captured

with each, the ecological consequences of raptor use of differing techniques assessed.

**2. The use that sympatric raptors make of different habitat types while hunting.** — Here, it is necessary to evaluate the time spent by raptors hunting in different habitat types (*see* Wakeley 1978a; Bechard 1982, for examples), because it is likely that prey availabilities differ among habitats (*see* USDI 1979 et seq.; Baker and Brooks 1981; Bechard 1982, for such findings). Perhaps only broad categories of habitat use by raptors need to be recognized, depending on the physiognomy and landscape units that characterize the study site. For interesting examples of ad-hoc habitat categorizations *see* USDI (1979 et seq.).

**3. The hunting success of sympatric raptors in different habitat types and in using different hunting techniques.** — The hunting success can be estimated as the number of successful prey strikes over the total hunting time spent by the different raptors. Unsuccessful prey strikes also should be counted to determine the hunting efficiency (successful strikes/total strikes with known outcome) of raptors using different hunting techniques (Collopy 1983a; Collopy and Koplin (*op. cit.*)). The prey captured ideally should be identified to the species level with the aid of adequate viewing devices. Direct observations are possible especially during the breeding season, when birds can be tracked to the nest after a successful prey strike, and the prey can be identified there if not at the capture site (e.g., Collopy 1983b). By focusing attention on open-terrain raptors, the prey captured in different parts of the habitat can be identified (e.g., Mendelsohn (*op. cit.*)).

**4. The presumable clues that sympatric raptors use in choosing hunting habitats.** — This is undeniably the most difficult part of the proposed research protocol. Judging from recent studies (e.g., Jaksic et al. 1981, 1982; Jaksic and Braker (*op. cit.*); Erlinge et al. (*op. cit.*)), generalist raptors appear to take prey in about the order of their respective availabilities in the field. Within characteristic upper and lower size thresholds scaled to the sizes of the individual raptor (whatever their abundance, hares are unavailable prey for American Kestrels the same way that grasshoppers are for Golden Eagles). Because prey are taken by raptors on a one-by-one basis, numerical estimates of the abundance of individual prey may well serve as a crude estimate of their availability in the different habitat

types recognized in the study site (*see* Baker and Brooks 1981; and Bechard 1982, for cautionary notes). Many techniques exist that can be used (e.g., Giles 1971), and examples of their applicability and relative success can be found in USDI (1979 et seq.). An additional characteristic of the prey species which may be important in affecting their selection by — or vulnerability to — raptors is their mobility (e.g., Huey and Pianka 1981). This feature can be evaluated as the average displacement in meters per activity period, with the specifics of the measurement depending on the type of prey. Ideally, a vulnerability index for the different prey species at the study site could perhaps be devised by combining prey characteristics such as density, spatial distribution (clumped, random, regular), micro-habitat use, mobility, size, conspicuousness, etc. How to compute such a complex index I cannot figure out, because vulnerability is not an inherent feature of the prey and should vary relative to raptor characteristics (size, habitat preferences, and hunting mode).

#### CONCLUDING REMARKS

The study of assemblage-level correlates of hunting behavior in raptors should prove illuminating for a number of important questions in community ecology: To what extent does the trophic structure of predator assemblages reflect the hunting behaviors of the component species?, and — more specifically — provided that falconiforms and strigiforms replace each other during the daily cycle, is the similar trophic structure of these raptor assemblages (Jaksic 1983) based on behavioral similarities in the hunting modes of their respective constituent species? To what extent do the differing hunting modes of sympatric predators facilitate their coexistence through reduction of co-use of food resources (exploitative competition)? What is the influence of interspecific agonistic interactions (interference competition) in the selection of hunting habitats and of hunting modes by sympatric raptors?

Autecological studies of raptors are abundant (*see* Clark et al. 1978 for a bibliography; Bunn et al. 1982, and Watson 1977, for specific studies), and raptor population ecology has long reached its maturity (*see* Newton 1979; Mikkola 1983, and references therein). However, community ecology of raptors is still in its infancy (*see* Jaksic and Braker 1983 for a cursory review). Given that raptors com-

pare more than favorably to other organisms (passerine birds, lizards) as model predators, I think the time is ripe for exploring this much neglected aspect of raptor ecology.

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# OWL WEIGHTS IN THE LITERATURE: A REVIEW

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**ABSTRACT** - Published mean body weights of 18 species of North American owls are presented and reviewed. Adequate data are lacking for virtually all species. A pattern of increased weight lability in small owl species is suggested by several studies of captive and wild birds. One source with large samples of weight data is rejected as its means deviate from virtually all other published sources.

Mean body weight is an important descriptive statistic used in many avian studies. Often, however, researchers do not handle large numbers of individual birds, and must rely on published mean weights for the species they are studying. This is especially true in the case of owls, which are difficult to capture and weigh in large numbers. In the course of compiling available weight data for all North American birds, I searched the literature for owl weights and noted some inconsistencies. The purpose of this paper is to review the published data, assess the reliability of different sources, and discuss general trends apparent from the data.

## MAJOR SOURCES

Most studies reporting owl weights contain very small samples, often only a single weight. Two sources do present weights of all or almost all North American species. Earhart and Johnson (1970) (hereafter, E&J) analyzed patterns of size dimorphism and food habits in owls. They presented weights (Table 1) and wing lengths for all North American owls except the Elf Owl (*Micrathene whitneyi*). E&J included 5 subspecies of the Great Horned Owl (*Bubo virginianus*) and 8 subspecies of Eastern and Western Screech-Owl (*Otus asio* and *O. kennicottii*). These weights were compiled from various museum collections. The sample sizes were often the largest reliable weight samples available for each species. E&J used these data to calculate the degree of sexual dimorphism for each species, and examined how various ecological parameters vary with body size. Snyder and Wiley (1976) also used this same data set to examine food stress and female nest defense as factors influencing reversed sexual dimorphism in hawks and owls. The data presented in E&J included sample size, mean and range for both sexes.

The second source with a large series of owl weights was Karalus and Eckert (1974) (hereafter, K&E). This is essentially a "coffee table book" with species accounts of all North American owls. It differs from the usual book of this type by including

detailed information of species' and subspecies' range, weight, linear measurements, voice and general behavior. The measurements initially seem attractive since they are based on large samples, sometimes larger than E&J (Table 1). Unfortunately, the data in this book appear to be completely unreliable. The acknowledgments imply that most measurements were taken from museum specimens, but no sources are cited. K&E also presented sample size, mean and range for at least 1 subspecies of each species, while an "average weight" was given for most other subspecies.

## SPECIES ACCOUNTS

***Tyto alba*** — Single weights of the Common Barn-Owl are given in Imler (1937) (475g, unsexed fall bird from Kansas) and Stewart (1952) (457g, unsexed fall bird from Ohio). Jackson and Dakin (1982) gave weights of 2 ♂♂ from Mississippi (492, 512g). Poole (1938) reported the mean of 2 birds as 505g, while Haverschmidt (1948) listed the weights of 1 ♂ (485g) and 3 ♀♀ (446, 498, 558g) from Surinam. Hartman (1961) collected 4 ♀♀ ( $\bar{x}$  = 516g) and 4 ♂♂ ( $\bar{x}$  = 439g). His birds were from Panama, Florida and Ohio, so weights cannot be ascribed to any one locality with confidence. Marks and Marti (1984) gave the mean of 78 birds as 511g. All these weights were within the range given by E&J.

Large samples are in Steenhof (1983) and Marti and Wagner (1985) (Table 1). Steenhof (1983) cited unpublished data. Her means were substantially higher, but within the range presented in E&J. Marti and Wagner (1985) presented data for live (Table 1), trauma-killed, and starved owls from northern Utah in winter. Both starved (♀  $\bar{x}$  = 392g, N = 25; ♂  $\bar{x}$  = 335g, N = 28) and trauma-killed (♀  $\bar{x}$  = 434g, N = 14; ♂  $\bar{x}$  = 361g, N = 7) birds weighed less than live trapped owls. In addition, the starved birds weighed less than the trauma-killed, demonstrating that the manner in which weight data is collected can affect means recorded for a sample. K&E's data were similar to

Table 1. Large samples of published weights (g) for North American owls. Data are presented as:  $\bar{x}$  (sample size) range.

SPECIES	EARHART & JOHNSON 1970	KARALUS & ECKERT 1974	OTHER SOURCES
<i>Tyto alba</i>	♀ 490(21) 382-580 ♂ 442(16) 299-580	♀ 500(50) 383-573 ♂ 384(46) 312-508	♀ 571(109) Marti & Wagner 1985 ♂ 476(53) ♀ 561(50) Steenhof 1983 ♂ 461(28) ♀ 69.2(2) 60.3-78.2 Johnson & Russell 1962 ♂ 55.9(11) 48.8-66.1 ♀ 194(66) 150-235 Henny & VanCamp 1979 ♂ 167(31) 140-210
<i>Otus flammeolus</i>	♀ 57.2(9) 51-63 ♂ 53.9(56) 45-63	♀ 137(7) 122-149 ♂ 126(6) 114-143	
<i>Otus asio naevius</i>	♀ 184(36) 126-252 ♂ 160(38) 99-229	♀ 208(49) 174-222 ♂ 200(38) 166-212	
<i>O. a. mcallii</i>	♀ 131(10) 115-162 ♂ 125(12) 94-154	182 ave.	
<i>Otus kennicottii inyoensis</i>	♀ 155(12) 135-173 ♂ 132(10) 119-149	204 ave.	
<i>O. k. cinerascens</i>	♀ 123(18) 92-160 ♂ 111(35) 88-137	166 ave.	
<i>O. k. kennicottii</i>	♀ 186(11) 152-215 ♂ 152(14) 130-178	236 ave.	
<i>O. k. bendirei</i>	♀ 157(23) 100-223 ♂ 141(49) 100-173	216 ave.	
<i>O. k. quercinus</i>	♀ 152(10) 130-164 ♂ 134(26) 108-170	216 ave.	
<i>Otus trichopsis</i>	♀ 92.2(8) 79-121 ♂ 84.5(23) 70-104	♀ 170(7) 156-187 ♂ 161(4) 146-174	
<i>Bubo virginianus wapacuthu</i>	♀ 1556(12) 1357-2000 ♂ 1239(10) 1035-1389		
<i>B. v. virginianus</i>	♀ 1768(29) 1417-2503	♀ 1597(51) 1454-1876	♀ 1758(209) 1197-2313 Langenbach & McDowell 1939
<i>B. v. virginianus</i>	♂ 1318(22) 985-1588	♂ 1449(33) 1383-1692	♂ 1343(206) 703-1703
<i>B. v. occidentalis</i>	♀ 1555(18) 1112-2046 ♂ 1154(18) 865-1460		♀ 1559(9) 1505-1652 Immler 1937 ♂ 1269(4) 1230-1360 U 1460(14) Jaksic & Marti 1984 U 1166(30) Jaksic & Marti 1984
<i>B. v. pacificus</i>	♀ 1312(23) 825-1668 ♂ 992(26) 680-1272	1384 ave.	
<i>B. v. pallascens</i>	♀ 1142(12) 801-1550 ♂ 914(18) 724-1257.		

(Table 1 Cont'd)

(Table 1 continued)

(Continuation of Table 1.)

SPECIES	EARHART & JOHNSON 1970	KARALUS & ECKERT 1974	OTHER SOURCES
<i>Nyctea scandiaca</i>	♀ 1963(30) 1550-2690 ♂ 1642(27) 1320-2013	♀ 1707(40) 1593-2003 ♂ 1613(34) 1448-1840	
<i>Surnia ulula</i>	♀ 345(14) 306-392 ♂ 299(16) 273-326	♀ 252(9) 202-274 ♂ 226(19) 194-266	
<i>Glaucidium gnoma</i>	♀ 73.0(10) 64-87 ♂ 61.9(42) 54-74	♀ 44.8(8) 36.9-50.7 ♂ 40.8(8) 34.6-46.8	
<i>Glaucidium brasilianum</i>	♀ 75.1(16) 62-95 ♂ 61.4(29) 46-74	♀ 82.2(5) 71.4-88.2 ♂ 78.5(2) 65.5-85.1	
<i>Micrathene whitneyi</i>		♀ 26.1(30) 17.3-30.6 ♂ 25.2(11) 17.0-28.9	U 41.0(20) 35.9-44.1 Wallers 1981
<i>Athene cunicularia</i>	♀ 151(15) 129-185 ♂ 159(31) 120-228	♀ 214(21) 195-223 ♂ 203(18) 181-212	U 147(11) summer, Coulombe 1970 6 MMA U 186(11) winter ♀ 168(10) 126-210 Thomsen 1971 ♂ 172(12) 145-191 ♀ 149(5) Hartman 1961 ♂ 147(6)
<i>Strix occidentalis</i>	♀ 637(10) 548-760 ♂ 582(10) 518-694	♀ 502(13) 384-591 ♂ 391(11) 312-514	
<i>Strix varia</i>	♀ 801(24) 610-1051 ♂ 632(20) 468-774	♀ 506(12) 388-651 ♂ 396(9) 330-569	
<i>Strix nebulosa</i>	♀ 1298(6) 1144-1454 ♂ 935(7) 790-1030	♀ 1391(8) 1078-1524 ♂ 1289(5) 1057-1385	
<i>Asio otus</i>	♀ 279(28) 210-342 ♂ 245(38) 178-314	♀ 282(16) 227-333 ♂ 258(11) 215-299	
<i>Asio flammeus</i>	♀ 378(27) 284-475 ♂ 315(20) 206-368	♀ 336(6) 276-429 ♂ 287(3) 261-346	♀ 379(8) 323-441 Clark & Ward 1974 ♂ 325(9) 294-368
<i>Aegolius funereus</i>	♀ 140(4) 121-160 ♂ 102(5) 85-119	♀ 224(23) 199-235 ♂ 211(26) 193-227	♀ 167(96) 126-194 Glutz et al. 1979 ♂ 101(74) 90-113
<i>Aegolius acadicus</i>	♀ 90.8(18) 65-124 ♂ 74.9(27) 54-96	♀ 107(31) 87.9-124 ♂ 102(37) 84.3-119	U 91.2(68) 72-112 Mueller & Berger 1967



E&J for females, but underestimated the male weight by 13%. As is true of most other species, too few data have been published to examine geographical variation.

***Otus flammeolus*** — Johnson and Russell (1962) presented mean weights for 13 Flammulated Owls from California and Nevada (Table 1). The mean for 11 ♂♂ is similar to E&J's mean for 56 ♂♂. The female mean in Johnson and Russell is substantially higher, but sample sizes are small. K&E's data are widely divergent from both of the above sources, deviating from E&J by 130 - 140%.

***Otus asio* and *O. kennicottii*** — Eastern and Western Screech-Owls contain 16 subspecies combined that are widely divergent in size (A.O.U. 1957, but see Marshall 1967). The only source covering all 16 subspecies is K&E, but as has been shown for most other species, these weights are at odds with virtually all other available sources. E&J provided weights for 2 subspecies of Eastern Screech-Owl (*naevius*, *mccallii*) and 5 subspecies of Western Screech-Owl (*inyoensis*, *cinerascens*, *kennicottii*, *bendirei*, *quercinus*). A large degree of geographic variation is apparent from this data set.

Other sources of screech-owl weights are few. I found no data for *aikeni*, *asio*, *brewsteri*, *hasbroucki*, *maxwelliae*, and *swenki*. Johnson and Russell (1962) collected 1 ♀ *macfarlanei* in California weighing 177g. Miller and Miller (1951) presented data from Arizona and California for 3 southwestern subspecies: *yumanensis* (6 ♂♂,  $\bar{x} = 103g \pm 11.4S.D.$ ), *inyoensis* (2 ♀♀,  $\bar{x} = 157g$ ); 8 ♂♂,  $\bar{x} = 131g \pm 9.2$ ), and *quercinus* (7 ♂♂,  $\bar{x} = 117g$ ). Miller and Miller's *inyoensis* data were similar to E&J, while the *quercinus* mean of Miller and Miller was less.

Clench and Leberman (1978) gave a mean of 163g (range 153-176g) for 8 *naevius* banded in Pennsylvania. Other *naevius* weights include Stewart (1937) (206, 228g unsexed adults) and Poole (1938) (2 birds averaging 178g). Kelso (1938) gave weights for *naevius* (2 ♂♂, 133, 156g; 9 ♀♀,  $\bar{x} = 201g$ , range 148-244g, New York, some birds starved), *floridans* (1 ♂, 111g, Florida), and 5 starved unsexed birds from Indiana ( $\bar{x} = 139g$ , range 114-162g), which Kelso attributes to *swenki* but considering the range must be *naevius* (A.O.U. 1957). Finally, Imler (1937) collected 4 individuals in western Kansas ( $\bar{x} = 152g$ , range 153-176g) which could be either *aikeni* or *swenki*.

The only complete analysis of seasonal weight

variation in screech-owls is the Henny and VanCamp (1979) study of *O. asio naevius* in Ohio. Their means of all birds captured were slightly higher than E&J for this subspecies (Table 1). Henny and VanCamp documented a seasonal weight cycle peaking in late fall. They suggest that this weight gain reflects an increase in fat reserves which aid winter survival. They also noted a wide range of body weights within seasons, suggesting that body weight was relatively labile. The same possibility has been discussed in studies of several other small owls.

***Otus trichopsis*** — The only additional weight published for the Whiskered Screech-Owl is an estimate of 120g (Zar 1969). This figure differs substantially from E&J. It could be that this estimate (which Zar did not make himself) was based on the incorrect assumption that Whiskered Screech-Owls should weigh approximately the same as the sympatric subspecies of Western Screech-Owl (*Otus kennicottii cinerascens*). K&E overestimated female and male means by 84 and 90%, respectively.

***Bubo virginianus*** — With the exception of E&J, surprisingly little data have been published on Great Horned Owls. E&J presented weights for 5 of the 9 North American subspecies. Other published weights are mostly of *virginianus*, the eastern subspecies. Hartman (1955) collected 1 ♀ (1248g) and 1 ♂ (1040g) from Ohio. The female weight was substantially lower than E&J's minimum for this subspecies. Poole (1938) gave the mean of 2 *virginianus* ♀♀ as 1446g. Langenbach and McDowell (1939) reported large samples of Pennsylvanian birds (Table 1). They noted a substantial difference between specimens with full stomachs (Table 1) and with empty stomachs (♀  $\bar{x} = 1644g$ ,  $N = 94$ ; ♂  $\bar{x} = 1263g$ ,  $N = 142$ ). The means from birds with full stomachs closely approximates E&J. The lower means for birds with empty stomachs show the amount of error that can be introduced if this factor is not accounted for.

For the other races, only scattered data are available. Irving (1960) collected a male *lagophonus* from Alaska weighing 1445g, while Williamson (1957) reported an Alaskan female *algistus* weighed 2000g. Poole (1938) gave one unsexed *pacificus* as 1480g. Imler (1937) listed a small sample of *occidentalis* from western Kansas (Table 1), while Jaksic and Marti (1984) presented samples for both *pacificus* and *occidentalis* (Table 1). In addition, Siegfried et

al. (1975) gave the mean weight of 2 ♀♀ as 1425g. These were from zoos and unidentified to subspecies.

By far the most surprising pattern is the lack of published data. Great Horned Owls are common throughout North America, and are often among the most common birds brought to raptor rehabilitation centers and museum collections. A large amount of unpublished data must exist on the various subspecies. No reliable data were found for the subspecies *saturatus* and *heterocnemis*.

**Nyctea scandiaca** — Irving (1960) gave the weight of 1 Snowy Owl collected in Alaska as 2267g, while Siegfried et al. (1975) listed 1 unsexed captive from Minnesota at 1916g. Poole (1938) reported a single male weighing 1404g, while Hagen (1942) gave a mean of 2003g for 7 Norwegian birds. Gesaman (1978) gave weights of 3 captive ♀♀ during the winter as 1928, 2175 and 2392g. The largest of these lost 80g during a 5-d fast. All these weights fall within the range given by E&J.

K&E's mean for males is close to E&J, but the female mean in K&E underestimates E&J by 13%. Even considering the weight loss recorded by Gesaman (1978) in a healthy fasting bird, this difference still may be real.

**Surnia ulula** — Small samples of Northern Hawk-Owl weights were found in Irving (1960), Campbell (1969) and Johnson and Collins (1975). Campbell (1969) collected 3 ♂♂ (317, 319, 346g) and 1 ♀ (418g) from Alaska, while Irving (1960) collected 2 Alaskan ♂♂ (322, 350g) and 4 ♀♀ (310, 336, 350, 384g). These were slightly heavier than the ranges in E&J. However, Johnson and Collins (1975) found a single captive bird's weight varied from 293-375g. Thus the above samples agree fairly well. K&E underestimated male and female weights by 24 % and 27%, respectively. The variation recorded by Johnson and Collins reflects the pattern of weight lability found in smaller owls.

**Glaucidium gnoma** — Several subspecies of Northern Pygmy-Owl occur in North America. Little data are available and it is impossible to determine if the wide differences reported are due to geographic variation or error. Johnson and Russell (1962) give weights of 8 ♂♂ ( $\bar{x}$  = 62.8g, range 57.3-68.0g) for the subspecies *californicum*, which agrees with the *californicum* weights of E&J. K&E weights are 34-38% lower than E&J, but are from a different subspecies (*pinacola*). Zar (1969) estimated

Northern Pygmy-Owl weights at 54g, substantially under the *californicum* samples, but without reliable data for the other subspecies, this estimate cannot be evaluated.

**Glaucidium brasilianum** — Little additional data exist for Ferruginous Pygmy-Owls. Prange et al. (1979) gave the weight of 1 bird as 61.0g. Russell (1964) collected 2 ♂♂ (60.5, 62.6g) and 4 ♀♀ (64.4, 74.6, 77.7, 94.8g) in Belize. These data agree closely with E&J. K&E overestimate female and male means by 10 and 28%, respectively. The wide range of values given by Russell (1964) and E&J may reflect weight lability in this species.

**Micrathene whitneyi** — E&J gave no weights for the Elf Owl. Zar (1969) estimated mean weight as 46g, only slightly larger than the large series mean of 41.0g in Walters (1981). Lasiewski and Dawson (1967) estimated the mean as 37.7g, while Ligon (1967) gave a range of 35-55g. Johnson (1968) listed 1 ♂ and 1 ♀ averaging 37.0g. Finally, Walters (1981) published a large series of weights based on banded, unsexed Arizona birds (Table 1).

**Athene cunicularia** — More data exists for Burrowing Owls than for any other North American owl. Two subspecies are represented: *hypugaea* in the west and *floridana* in Florida. Some published weights cannot be safely ascribed to subspecies. For example, Marti (1974) assembled 8 weights from literature and museum specimens ( $\bar{x}$  = 140g), but did not describe his sources more fully.

Most published samples are of *hypugaea*. Imler (1937) gave the mean of 7 Kansas birds as 149g (range 114-171g). Coulombe (1970) presents summer and winter weights from the same Californian population (Table 1). His samples show wide seasonal variation. Thomsen (1971) presents weights for breeding California birds (Table 1), that were heavier than E&J by less than 10%. K&E, on the other hand, overestimate E&J by 28-42%, probably a very real difference.

Of the published *floridana* weights, Prange et al. (1979) listed weights of 3 individuals (179, 182, 185g). Hartman (1955) included weights of 4 ♀♀ (130, 150, 157, 170g) and 4 ♂♂ (130, 150, 170, 170g), while Hartman (1961) listed weights of 5 ♀♀ and 6 ♂♂ (Table 1), possibly including the same data as the earlier paper. Little difference between the means for the 2 subspecies can be seen.

**Strix occidentalis** — Johnson and Russell (1962) collected 2 female Spotted Owls in California

weighing 616 and 648g. No other published weights were located except for E&J and K&E. K&E underestimated female weight by 21% and male weight by 33%. This difference appears very substantial, but could reflect subspecific differences. K&E's sample was based on *occidentalis*, while E&J did not give subspecific identification. Three subspecies of Spotted Owl occur in North America.

***Strix varia*** — Weights are available for 2 subspecies of Barred Owl. For subspecies *varia*, Hartman (1955) listed weights of 2 ♀♀ from Ohio (681, 771g) and 1 ♂ (642g), while Poole (1938) gave the weight of 1 unsexed bird as 510g. Both E&J and K&E samples are of this subspecies. K&E again seriously underestimated the E&J weights by 37% (both sexes). Siegfried et al. (1975) gave the weight of a single captive from Minnesota as 748g.

Hartman (1955, 1961) also gave weights for *georgica* ("alleni" in the 1961 paper). Hartman (1955) listed 1 ♀ (875g) and 3 ♂♂ from Florida (681, 750, 800g). Hartman (1961) gave 2 ♀♀ weights as 850, 875g, and the mean of 6 ♂♂ as 718 + 35.1 S.E. These few weights suggest that *georgica* might be heavier than *varia*, but sample sizes are much too small for firm conclusions.

***Strix nebulosa*** — Very little data exist for the Great Gray Owl. Irving (1960) collected 1 ♀ (1092g) in Alaska, while Bent (1938) stated that weights of 4 birds ranged "from 1 lb. 15 oz. to 2 lb. 14.5 oz." K&E's male means are substantially overestimated by 38%, compared to E&J.

***Asio otus*** — Graber (1962) gave the weight of a captive female and a captive male from Illinois as 310g and 252g, respectively. Poole (1938) listed 2 ♀♀ as averaging 288g, while Hagen (1942) reported a mean of 285g for 3 Norwegian birds. Marti (1974) compiled a mean of 262g from 7 weights found in the literature and museum specimens, and Marks and Marti (1984) gave a mean of 254g for 20 birds. All these weights fall within the range reported by E&J.

***Asio flammeus*** — A number of studies report the weight of a single Short-eared Owl. Irving (1960) collected 1 ♀ weighing 400g from Alaska. Imler (1937) found one unsexed bird in western Kansas weighed 270g. Campbell (1969) collected an Alaskan male weighing 337g. A captive in California averaged 385g over 14 d (Page and Whitacre 1975), while another captive in Illinois averaged 406g over

24 h (Graber 1962). In addition to these single reports, Clark (1975) reported the mean of 2 ♀♀ as 392g and 2 ♂♂ as 304g, while Hagen (1942) gave the mean of 11 Norwegian birds as 371g. Clark and Ward (1974) compiled a relatively large sample for both sexes (Table 1) which agree closely with E&J.

***Aegolius funereus*** — Irving (1960) collected an Alaskan male Boreal Owl (*A. f. richardsoni*) weighing 116g, while Campbell (1969) reported a very fat Alaskan female weighing 194g. E&J gave weights of only 9 birds. K&E have a much larger sample, but their data deviate from E&J by 60% for females and 107% for males and cannot be considered reliable. The best available sample for this species is Glutz von Blotzheim et al. (1980). Their sample (Table 1) is of the European subspecies *A. f. funereus*, however, the means and ranges overlap widely with E&J's small sample.

***Aegolius acadicus*** — Several small samples of weights were published for Northern Saw-whet Owls. Zar (1969) estimated a weight of 124g, which is very high compared to the following. Single weights were given by Gatehouse and Markham (1970) (82.9g, 1 captive ♂), Poole (1938) (108g, unsexed), and Murray and Jehl (1964) (89.6g, 1 New Jersey migrant). Graber (1962) weighed 2 captive birds, 1 ♀ (96g) and 1 ♂ (75g). Clench and Leberman (1978) banded 5 unsexed migrants in Pennsylvania ( $\bar{x}$  = 86.0g, range 72.6-97.6g), while Walkinshaw (1965) banded 10 migrants in Michigan weighing 95.2g (range 85.1-114g). All these weights agree closely with E&J's values.

Collins (1963) reported several series of Northern Saw-whet Owl weights. Eleven birds of both sexes from the University of Michigan collection averaged 81.8g (range 54.2-124g), while 7 banded birds weighed 82.7g (range 67.5-113g). Collins also kept 2 ♀♀ (106, 108g) and 1 ♂ (80g) in captivity. He noted that the weight of the lighter female varied daily from 74.1g to 114g, suggesting weight lability in this species.

Mueller and Berger (1967) weighed a large series of migrants in Wisconsin (Table 1). They documented a significant weight difference between adult and immature birds, and discussed weight change after banding. Their means and ranges for the unsexed birds agree relatively well with E&J. K&E overestimated female means by 18% and male means by 36% compared to E&J.

## DISCUSSION

The most apparent pattern in the preceding species accounts is the lack of published data even for common species and subspecies of owls. E&J provide a basic reference sample for most species. E&J's data were taken from specimens from several museums, and are probably adequate if a representative mean weight is needed, as in their study of owl food habits. But since individual specimens in a collection are often obtained in a wide variety of ways, the heterogeneity found in these samples precludes their use in many studies. A single sample like E&J's cannot express the seasonal (Coulombe 1970; Henny and VanCamp 1979), daily (Collins 1963) and geographic (Miller and Miller 1951) variation present in owls. Owls could provide a good test of ecotypic variation such as Bergmann's rule, as they are often permanent residents and have wide geographic ranges, but the available data simply do not allow such analyses. Published accounts typically are of small sample size or do not consider such variables as stomach content (Langenbach and McDowell 1939) or manner of collection (Marti and Wagner 1985). Thus, published series of weights within and between seasons for birds handled in a consistent manner are needed for virtually every species.

This situation is not unique to owls. In a compilation of weight data for all North American birds (Dunning 1984), I found that adequate data are lacking for a surprising number of species. This is especially true for western and southwestern species. However, I often found that pertinent data existed in some bander's log or researcher's notebook, but remained unpublished. A single example of the value of more published data will suffice. Henny and VanCamp (1979) proposed that the increase in mean body weight recorded in the fall reflects an increase in fat reserves allowing greater winter survival for a population of Eastern Screech-Owls in northern Ohio. One way to test this hypothesis would be to examine seasonal weight cycles in more southerly screech-owl populations. If a similar fall peak in body weight were found in screech-owls that lived in a more mild climate, an alternative explanation might be required. However, this test is presently impossible to do, as I could find no weights at all for the more southerly subspecies in the eastern United States, *O. a. asio*!

A second pattern of great interest is that of increased weight lability in small owl species. Collins

(1963) reported that the weight of a single captive female Northern Saw-whet Owl varied from 74.1g to 114g, a variation of 30% from the median. Similarly, Johnson and Collins (1975) reported weight of a female captive Northern Hawk-Owl varied from 293g to 375g "without apparent ill effect." In comparison, Gessaman (1978) found that a female Snowy Owl lost only 80g (3.3% of this individual's mean weight of 2392g) during a 5-d fast. If this weight loss had been in the same proportion as the Northern Saw-whet Owl reported by Collins, the female Snowy Owl could have lost up to 718g. With these captivity studies in mind, the wide within-season range of Eastern Screech-Owl weights reported by Henny and VanCamp (1979) and the large between-season variation in Burrowing Owl weights reported by Coulombe (1970) suggest that weight lability may be common in many smaller owls.

Finally, it is apparent from this review that Karalus and Eckert (1974) is totally unreliable. The mean weights presented in this work deviate from virtually all other samples by as much as 140%. The weight lability just discussed could lead to widely divergent weights sometimes being reported for a small owl. But the K&E data are supposedly based on large samples, and the deviations are present in both large and small species. A spot check of some of the linear measurements presented for each species shows that these, too, deviate from published references by as much as 20%. Since other reviewers have found fault with the text, terminology, bibliography (Martin 1976) and maps (Bock 1976) in this work, it is apparent that this book cannot be used as a reliable source of any information on owls.

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# EVAPORATIVE WATER LOSS OF CAPTIVE COMMON BARN-OWLS

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**ABSTRACT** — Evaporative water loss of the Common Barn-Owl (*Tyto alba*) was examined at temp experienced by these owls during incubation. Water loss increased ( $P < 0.001$ ) with increasing ambient temp; however, it appeared that Common Barn-Owls in Utah would not be heat-stressed during incubation.

The Common Barn-Owl (*Tyto alba*) readily uses man-made structures (i.e., barns, haylofts, abandoned water towers) as roosting and nesting sites and adapts quickly to the use of nestboxes (Otteni et al. 1972; Marti et al. 1979). The use of nestboxes as nesting sites provides the barn owl with the advantageous effects of the sheltered nestboxes (i.e., decreased forced convection, less direct exposure to precipitation, and higher than ambient temp) during incubation (Hamilton 1982). While there may be advantages for birds to conduct incubation within nestboxes, higher ambient temp may be a potential stressor. Birds may mitigate the effects of heat stress by panting, gular fluttering, or by postural thermoregulatory behavior (Bartholomew et al. 1968; Weathers 1972; Bartholomew and Dawson 1979; Dawson 1982).

The objectives of this study were to examine evaporative water loss of barn owls, and to determine whether water loss plays a crucial role during incubation at ambient temp below 32°C.

## MATERIALS AND METHODS

Two adult owls were captured in April 1980 at Welder Wildlife Foundation (Sinton, San Patricio Co., Texas) and a third adult owl was obtained from a local raptor rehabilitator (S. Ure, Salt Lake City, Utah). All birds were transported to the Environmental Physiology Laboratory at Utah State University, Logan, Utah. In 1981, three additional adult owls were captured post-incubation (April-May, Brigham City, Box Elder Co., Utah) and likewise transported to the laboratory facilities. All owls (♀) were housed in separate 3 x 3 x 2.5 m walk-in environmental chambers. Owls were fed a laboratory House Mouse (*Mus musculus*) diet and maintained on a 12L:12D photoperiod during all experimental trials.

Evaporative water loss of 6 captive barn owls was measured at temp that simulated nesting temp (2-30°C). An owl was equilibrated to the test temp for 2-3 d before an experiment and fasted for 6 h prior to the experiment. Each owl was weighed to the nearest 1.0 g on a platform balance and placed in a metabolism chamber. Owl weights ranged from 527.0-584.4 g with a mean value of 561.3 g ( $\pm 27.8$ , S.D.). Metabolism chambers (56 x 46 x 43 cm) were constructed of plywood (1.3 cm) with a plexiglass sliding door unit (30 x 22 cm, inside dimensions). All edges of the chamber and door were sealed airtight with liquid plastic to prevent extraneous air flow. The wood was varnished and the inner surface of the chamber was covered with a plastic coating to prevent water vapor from being bound hydroscopically to the walls of the metabolism chamber. Condensation was never noted

on the walls of a chamber. Air inlet and outlet valves were positioned on opposite sides of the chamber to allow airflow through the chamber.

After closure of the sliding door of the metabolism chamber, a diaphragm pump (dynapump) was started and respiratory gases were pulled through plastic tubing and then through a series of preweighed U-tubes which were filled with Drierite and weighed to the nearest 0.01 g, analytical balance. The weight change in the Drierite equalled the water vapor expired by the owl plus the atmospheric water vapor. A second set of Drierite U-tubes was connected in parallel to measure atmospheric water vapor (same pump). The rates of air flow from the metabolism chamber and the second set of tubes were equal. Water vapor expired by the owl ( $\text{mg H}_2\text{O/g.h}$ ) was calculated as the difference in weight between the experimental and control tubes.

Air temp inside the metabolism and environmental chambers was monitored with thermistors (Model No. 1331, Control Equipment Co., Salt Lake City, Utah) and copper-constantan thermocouples and recorded on Rustrak chart recorders (Model No. 2133, Control Equipment Co.) and Wescor thermometers (Model No. TH50 TC, Wescor Co., Logan, Utah), respectively. Thermistors and thermocouples were calibrated with a glass mercury thermometer. Temp was recorded every 15 min.

Statistical analysis of data presented here included curvilinear regression analysis and paired t-Test.

## RESULTS AND DISCUSSION

Evaporative water loss of barn owls was examined over a temp regime (2-30°C) which simulated ambient temp experienced by incubating barn owls (Hamilton 1982).

To test the physical effect of the metabolism chamber in altering the temp experienced by an owl, ambient (environmental chamber) temp and temp of the metabolism chamber were monitored during each experimental trial. Experimental temp was separated into 3 temp ranges: 0-10°C, 11-20°C and 21-30°C. In each temp range, the temp of the metabolism chamber was significantly higher ( $P < 0.001$ , paired t-Test) than the temp of the environmental chamber. The temp difference between the metabolism chamber and the environmental chamber was greatest ( $P < 0.001$ , 2.0°C) at temp which ranged between 0-10°C, and also was significantly higher for temp between 11-20°C (0.7°C) and 21-30°C (0.6°C). Therefore, owls utilizing nestbox metabolism chambers experience higher temp than would be seen if using open sites.

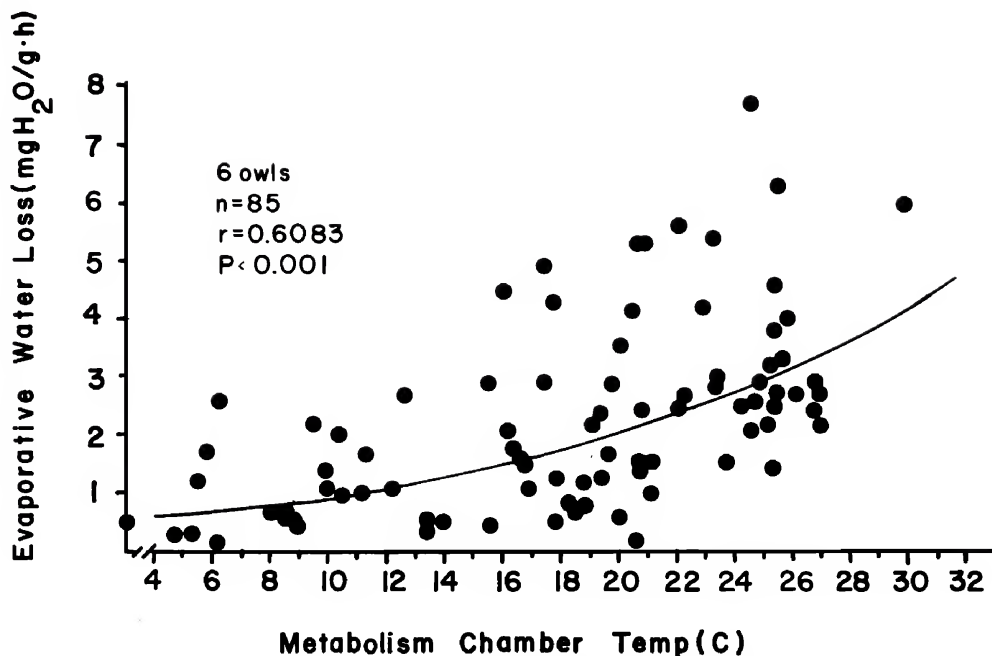


Figure 1: Water loss (mg H<sub>2</sub>O/g·h) of 6 captive barn owls.

Eighty-five measurements from 6 captive barn owls showed that water loss (mg H<sub>2</sub>O/g·h) increased significantly ( $P < 0.001$ ) as ambient temp increased (Fig. 1). Recent studies by Wunder (1979), Weathers (1979, 1981), and Dawson (1982) have examined climatic adaptation, physiological thermoregulation and water loss from birds and the data exhibited by the barn owl does not deviate from established patterns. Water loss of barn owls at ambient temp from 0-20°C is not different than data for non-incubating pigeons (*Lophophaps ferruginea*) (Dawson and Bennett 1973) or Burrowing Owls (*Athene cunicularia*) (Coulombe 1970).

Coulombe (1970), Dawson and Bennett (1973) and Weathers (1981) have shown that the pattern of evaporative water loss of birds is an exponential function. However, water loss is essentially linear until approximately 35-40°C at which time birds become heat-stressed (Dawson 1982) and the water loss increased exponentially. This is also seen in Figure 1; at temp that mimics incubation temp (up to 30°C) water loss of barn owls is fairly linear and not very substantial. However, barn owls in Utah do not experience nestbox temp greater than 32°C during incubation (Hamilton 1982); therefore, the

barn owl in Utah may be able to conduct incubation without an apparent heat stress.

In summary, birds must contend with numerous environmental stresses during incubation, one of which is heat stress. Some birds utilize roost sites with low heat loads (Barrows 1981), while other incubating birds use postural thermoregulatory behavior to reduce heat stress (Lustick et al. 1978, 1979; Bartholomew and Dawson 1979). The barn owl may escape heat stress problems during incubation by using nestboxes and by choosing a location where high ambient temp does not occur.

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# PEREGRINE FALCON SEMEN: A QUANTITATIVE AND QUALITATIVE EXAMINATION

JOHN HOOLIHAN AND WILLIAM BURNHAM

**ABSTRACT** — Collection frequencies and certain characteristics of Peregrine Falcon (*Falco peregrinus*) semen were investigated using semen from a falcon trained to copulate on a specially designed hat. Semen volume increased significantly when collections were increased from two to three times/day, but cells/ejaculate decreased. No significant difference in number cells/ejaculate or cells/microliter was detected between morning and evening samples with two collections/day. Three collections/day resulted in decreasing total cell numbers/collections and numbers/microliter with the most cells collected during the initial morning collection. Semen showed a high motility, with estimated 80 - 100% of sperm cells alive.

The Peregrine Falcon (*Falco peregrinus*) continues to be a focal point of captive propagation efforts (Cade and Dague 1981). An important technique used in captive propagation is artificial insemination, since many captive falcons do not copulate (Boyd 1978). The technique of artificial insemination has been described by Boyd et al. (1977), but little attention has been directed toward quantitative or qualitative examination of falcon semen. We report here the affect of increasing frequency of semen collection upon semen volume and upon certain characteristics of peregrine semen, including concentration of sperm cells, total cells/ejaculate, motility and percent of viable sperm cells.

## MATERIALS AND METHODS

We wished to know if daily semen volume could be increased significantly by collecting semen 3 times/d vs 2 times/d. Two periods were designated near the midpoint of the semen production cycle (Table 1). Period I comprised 9 d when semen was collected 2 times/d, between 0800 H and 1015 H, and between 1715 H and 1745 H. A third collection was accomplished between 1300 H and 1345 H in Period II. Three days separated the two 9-day collection periods.

All semen in this study was collected from a 10-year-old peregrine. The falcon was behaviorally imprinted to humans and copulated on a specially constructed hat (Cade and Dague 1981). The falcon was handled and raised as described by Boyd and Schwartz (1981). The falcon was given the opportunity to copulate on the hat only during the period when semen was needed for artifi-

Table 1. Means (ranges in parentheses) of semen volume and sperm counts of a 10-year-old Peregrine Falcon.

TIME	VOL/DAY	CELLS/ $\mu$ l x $10^3$	CELLS/EJACULATE x $10^6$
Period I	150 (116 - 185) (n=9)	52.86 (38.12 - 81.12) (n=8)	4.46 (2.55 - 5.84) (n=8)
0800 - 1015 H		59.06 (45.62 - 81.12) (n=4)	4.97 (3.51 - 5.84) (n=4)
1715 - 1745 H		46.66 (38.12 - 55.88) (n=4)	3.95 (2.55 - 4.97) (n=4)
Period II	192 (175 - 208) (n=11)	37.12 (26.25 - 60.62) (n=15)	2.46 (1.27 - 3.88) (n=15)
0800 - 1015 H		47.54 (40.00 - 60.62) (n=3)	3.32 (2.76 - 3.88) (n=3)
1300 - 1345 H		36.47 (30.38 - 39.88) (n=7)	2.61 (1.77 - 3.23) (n=7)
1715 - 1745 H		31.78 (26.25 - 37.38) (n=5)	1.72 (1.27 - 1.90) (n=5)

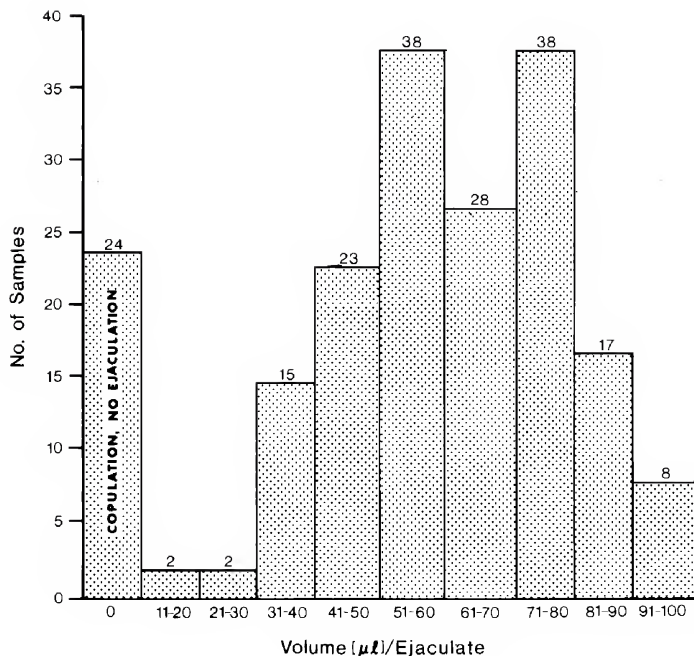


Figure 1. Semen production of a 10-year-old Peregrine Falcon.

cial insemination. The semen was retrieved from the hat by use of blood capillary tubes. The capillary tubes were initially calibrated for volume by using a micropipette. Each millimeter (mm) of tube length represented 1 microliter ( $\mu$ l) of semen. Volume was therefore easily calculated by measuring the length of semen in the tube with a metric rule.

Concentration of spermatazoa per sample was calculated by the use of a phase contrast hemocytometer. Separate means were calculated for the morning and evening collections since the collections were not evenly spaced over each 24 hr period.

Standard poultry science methods for determining the percent of viable sperm were inadequate for peregrine semen quantification. Use of a live-dead stain was not helpful in determining fertilization capacity. The nigrosin, eosin blue stain (Ernst 1970) which is intended to darken only dead cells, permeated both live and dead cells of the falcon semen. This technique needs to be perfected for falcons.

Motility score of the semen was judged qualitatively. Samples were taken immediately to the laboratory once collected and mixed thoroughly in small vials pre-warmed to 37°C. Semen samples were then placed on pre-warmed slides which were kept at 37°C in a microscope stage incubator and viewed through a phase contrast microscope. Motility was judged qualitatively by the progressive motion and speed of the sperm cells, as well as the estimated percent of moving cells.

## RESULTS AND DISCUSSION

The 10-year-old male peregrine commenced copulation on 5 March and continued on a daily basis through 1 June when the opportunity to copulate was no longer made available to him, thus representing a semen production period of 95 d. Semen produced per copulation ranged from 0 (copulation, but no ejaculation) to 93 ml. Figure 1 compares the volume produced/ejaculate with frequency of ejaculation for periods of both 2 and 3 collections/d. Semen volume rose significantly (28%,  $P < 0.001$ , Mann-Whitney U-test) when collections were increased from 2 to 3 times/d, but cells/ejaculate decreased significantly ( $P < 0.01$ ) when collection frequency was increased (Table 1).

During Period I, no significant difference ( $P = 0.20$ ) in number of cells/ $\mu$ l or cells/ejaculate between morning or evening samples was observed (Table 1). In contrast, in Period II a significant difference ( $P < 0.025$ ) existed in number of cells/ $\mu$ l and cells/ejaculate between the 3 collection times. The mean number of cells/ $\mu$ l for the morning collection of Period II of  $47.54 \times 10^3$  shows a decrease of 19% compared

with the same time in Period I (Table 1). The midday and evening collections for Period II had mean values of  $36.47 \times 10^3$  and  $31.78 \times 10^3$  cells/ $\mu$ l, respectively, the latter showing a decrease for the evening collection times. Total sperm cells/ejaculate (in the morning collections of Period I) averaged  $4.97 \times 10^6$  (Table 1), and evening collections averaged  $3.95 \times 10^6$  cells/ejaculate. Together, these figures represent a daily total average of  $4.46 \times 10^6$  spermatazoa/ejaculate for Period I. In contrast, the mean for the morning, midday and evening collections of Period II were  $3.32 \times 10^6$ ,  $2.61 \times 10^6$  and  $1.72 \times 10^6$ , respectively (Table 1). We initially presumed that Period II would show a decrease in spermatazoa/ejaculate and an overall daily total greater than Period I. However, fewer total cells were produced in Period II.

The semen collected showed a high motility value for more than 92% of the samples ( $n = 41$ ) analyzed with an estimated 80 - 100% of the sperm cells alive and moving in a progressive motion. The speed with which the sperm cells move is difficult to evaluate with respect to their apparent fitness. It should be possible to correct this problem through the examination of samples from other captive and wild falcons. In this way, comparisons could be made and the normal speed could be ascertained. Semen from the peregrine tested fertilized eggs at a level equal to other donors of varying ages.

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Adult male Prairie Falcon and young at a typical Mojave Desert nest-site. Artwork by N. John Schmitt.

# PRAIRIE FALCON PREY IN THE MOJAVE DESERT, CALIFORNIA

DOUGLAS A. BOYCE, JR.

**ABSTRACT** — Twenty-five species of birds, 9 species of mammals, 5 species of reptiles and 1 species of insect were represented in prey remains and castings from 19 Prairie Falcon (*Falco mexicanus*) nests in the Mojave Desert, California, during 1977 and 1978. Reptiles represented a greater proportion in the diet than is reported in most other Prairie Falcon food studies in the western United States. The Horned Lark (*Eremophila alpestris*), Mourning Dove (*Zenaidura macroura*), Valley Pocket Gopher (*Thomomys bottae*) and Desert Woodrat (*Neotoma lepida*) were found in over 50% of the nests. Eighty-four percent of the prey weighed less than 150 g. The mean prey weight was 107 g and equals 20% of the weight of male Prairie Falcons.

The Prairie Falcon (*Falco mexicanus*) is considered a generalist in prey selection (Bent 1938: Part 2). Mammals and birds are the most common prey taken, with specific prey frequencies varying regionally (Tyler 1923; Fowler 1931; Enderson 1964; Brown and Amadon 1968; Leedy 1972; Ogden 1973; Denton 1975; Haak 1982). Reptiles and insects are rarely recorded as prey (Table 1), although Snyder and Wiley (1976) reported an unusual reliance on insects for food. Types of prey selection by Prairie Falcons nesting in the Mojave Desert contrast sharply with prey previously recorded for this area. Pierce (1935) and Fowler (1935) reported a nest in the Mojave Desert where young Prairie Falcons were raised entirely on a diet of reptiles — mainly Chuckwalla (*Sauromalus obesus*) and occa-

sionally Collared Lizard (*Crotaphytus collaris*), while Bond (1936) reported exclusively mammalian prey in 41 castings at another Mojave Desert nest. Because little is known about food habits of Prairie Falcons in the Mojave Desert, I studied this aspect of their biology.

## METHODS

Prey remains and castings were collected from 19 falcon nests throughout the Mojave Desert (34° N 116° W) between March and June 1977 and 1978 in order to provide a qualitative summary of Prairie Falcon food habits. Prey remains and castings were also collected from immediately below the nest site when known to have come from no other raptor. Prey remains were identified in the field or compared with specimens at Humboldt State University, Arcata, California. Fresh weights for prey items were obtained from the Museum of Vertebrate Zoology, University of California, Berkeley, California. I used an adjusted weight

Table 1. Frequency (%) of birds, mammals, reptiles and insect prey remains in Prairie Falcon nests in the western United States.

SOURCE	LOCATION	MAMMALS	BIRDS	REPTILES	INSECTS
Fowler (1931)	California	30 <sup>c</sup>	70	0	0
McKinley unpubl. <sup>a</sup>	Colorado	55	45	0	0
Marti and Braun (1975)	Colorado	39	61	0	0
Ogden (1973)	Idaho	53	33	14	trace
S.R.B.P. <sup>b</sup> (1979)	Idaho	22	72	6	0
Platt (1974)	New Mexico	37	54	9	0
Voelker unpubl. <sup>a</sup>	Oklahoma	8	92	0	0
Porter and White (1973)	Utah	8	92	0	0
Smith and Murphy (1973)	Utah	31	50	0	19
This Study	Mojave Desert	52	38	10	trace

<sup>a</sup>data from Sherrod (1978:96, 97)

<sup>b</sup>Snake River Birds of Prey annual report 1979

<sup>c</sup>rounded to nearest 1%

of 500 g for rabbit species in Table 2 because, from the available information, it is unlikely Prairie Falcons are capable of carrying anything heavier (see discussion below).

Quantifying prey remains and castings collected from hawk nests during the nesting season is biased and unreliable (Errington 1932; Craighead and Craighead 1956). Some castings and prey remains may be deposited by falcons before nesting begins and persist until collection during the nesting season. Furthermore, Fowler (1931) reported that adult Prairie Falcons remove uneaten prey and castings from nests. Haak (1982) reported that a larger variety of prey was found at nests than was hunted, suggesting over-representation of uncommonly used prey at nests; however,

observations of encounters with some prey species may be difficult to make. Prey remains may also underestimate the numbers of small rodents and birds actually captured (Cade 1960). Because of numerous potential biases, food habits reported here are qualitative not quantitative.

Delineation of the Mojave Desert boundaries closely parallels the outer distributional limits of the Joshua Tree (*Yucca brevifolia*) (Jaeger 1957). Creosote (*Larrea divaricata*) and Burro Bush (*Fanseria dumosa*) are also characteristic desert flora. Alkali sinks, creosote bush scrub, shadscale scrub, Joshua Tree woodland, and Pinyon-Juniper woodland form the major Mojave Desert floral communities (Munz and Keck 1959).

Table 2. Prey items identified at Prairie Falcon nests in the Mojave Desert.

SPECIES	NO. <sup>a</sup> NESTS	% <sup>b</sup> NESTS	ESTIMATED WEIGHT (g)
<b>MAMMALS</b>			
California Ground Squirrel ( <i>Spermophilus beecheyi</i> )	2	10.5	565
Mojave Ground Squirrel ( <i>Spermophilus mohavensis</i> )	5	26.0	177
Whitetail Antelope Squirrel ( <i>Ammospermophilus leucurus</i> )	4	21.0	113
Valley Pocket Gopher ( <i>Thomomys bottae</i> )	12	63.0	88
Pocket Mouse ( <i>Perognathus</i> sp.)	5	26.0	19
Kangaroo Rat ( <i>Dipodomys</i> sp.)	5	26.0	41
Deseret Woodrat ( <i>Neotoma lepida</i> )	11	58.0	105
Black-tailed Jack Rabbit ( <i>Lepus californicus</i> )	2	10.5	500
Desert Cottontail ( <i>Sylvilagus audubonii</i> )	2	10.5	500
<b>BIRDS</b>			
Chukar ( <i>Alectoris chukar</i> )	3	15.8	500
Western Sandpiper* ( <i>Calidris mauri</i> )	1	5.3	27
Rock Dove ( <i>Columba livia</i> )	2	10.5	393
Mourning Dove ( <i>Zenaidura macroura</i> )	8	42.1	109
White-throated Swift ( <i>Aeronautes saxatalis</i> )	1	5.3	36
Western Kingbird ( <i>Tyrannus verticalis</i> )	2	10.5	41
(Table 2 continued)			

(Continuation of Table 2)

**BIRDS (cont'd)**

Say's Pheobe*			
( <i>Sayornis saya</i> )	1	5.3	25
Horned Lark			
( <i>Eremophila alpestris</i> )	12	63.2	28
Cactus Wren*			
( <i>Campylorhynchus brunneicapillus</i> )	1	5.3	37
Rock Wren			
( <i>Salpinctes obsoletus</i> )	3	15.8	11
Sage Thraasher*			
( <i>Oreoscoptes montanus</i> )	1	5.3	44
LeCont's Thrasher*			
( <i>Toxostoma lacontei</i> )	1	5.3	62
Mountain Bluebird			
( <i>Sialia currucoides</i> )	1	5.3	2.7
Loggerhead Shrike			
( <i>Lanius ludovicianus</i> )	1	5.3	45
European Starling			
( <i>Sturnus vulgaris</i> )	2	10.5	77
Black-headed Grosbeak*			
( <i>Pheucticus melanocephalus</i> )	3	15.8	46
White-crowned Sparrow			
( <i>Zonotrichia leucophrys</i> )	1	5.3	2
Western Meadowlark			
( <i>Sturnella neglecta</i> )	5	26.3	103
Red-winged Blackbird			
( <i>Agelaius phoeniceus</i> )	2	10.5	56
Brewer's Blackbird			
( <i>Euphagus cyanocephalus</i> )	3	15.8	58
Scott's Oriole*			
( <i>Icterus parisorum</i> )	2	10.5	38
Northern Oriole*			
( <i>Icterus galbula</i> )	1	5.3	27
Western Tanager			
( <i>Piranga ludoviciana</i> )	4	21.1	31
House Sparrow			
( <i>Passer domesticus</i> )	4	21.1	27
House Finch			
( <i>Carpodacus mexicanus</i> )	1	5.3	20

**REPTILES**

Desert Iguana*			
( <i>Dipsosaurus dorsalis</i> )	1	5.3	56
Chuckwalla			
( <i>Sauromalus obesus</i> )	4	21.0	235
Zebra-tailed Lizard*	1	5.3	
( <i>Callisaurus draconides</i> )			2
Desert Horned Lizard			
( <i>Phrynosoma platyrhinos</i> )	4	21.0	22
Western Whiptail			
( <i>Cnemidophorus tigris</i> )	2	10.5	1

<sup>a</sup>The number of nests in which a species was recorded.<sup>b</sup>The number of nests in which a species was found divided by the number of nests examined (N = 19); times 100 and reported as a percentage.

\*Species not previously recorded in the literature as Prairie Falcon prey.

## RESULTS AND DISCUSSION

Thirty-nine species representing 3 vertebrate classes were present in prey collections from 19 nests (Table 2). Twenty-five species of birds, 9 species of mammals and 5 species of reptiles were identified. Insect parts were rarely noted and only 1 species, Armored Stink Beetle (*Eleodes armata*) was identified. The Horned Lark, Valley Pocket Gopher and Desert Woodrat were present in over 50% of the nests. The Mourning Dove was present in 48% of the nests.

Although the number of avian species captured outnumbered mammals by almost 3 to 1, the mean weight for birds (76 g) was half of the mean weight for mammals (179 g) suggesting greatest energetic return results from capturing mammals. Analysis of 214 pellets provides further evidence that mammals might be captured more often than birds or reptiles. Mammals were present in 72%, birds in 24% and reptiles in 4% of the pellets examined.

In contrast to Pierce (1935) and Bond (1936) I found no instance where all or nearly all prey items were from just one vertebrate class. No single species appears as primary prey on a desert-wide basis (Table 2). Some species were infrequent in prey remains desert-wide but were locally frequent. For example, the Black-headed Grosbeak (*Pheucticus melanocephalus*) was collected from 3 nests located along the east side of the Sierra Nevada Mountains but nowhere else in the desert. One nest had 8 grosbeaks present.

**Mammals.** The Valley Pocket Gopher and Desert Woodrat were found in over 50% of the nests. They were seldom seen except very early in the morning or late in the evening when temperatures were cooler. Their high abundance in the prey remains suggests that they were captured at these times. Harmata et al. (1978) found that Prairie Falcons forage primarily during early morning and late afternoon in the Mojave Desert.

Blacktailed Jackrabbit (*Lepus californicus*) and Desert Cottontail (*Sylvilagus audubonii*) feet were found in falcon nests. Adult Blacktailed Jackrabbit (2,590 g) and Desert Cottontail (1,700 g) weigh 3 to 5 times as much as adult male Prairie Falcons (554 g, Enderson 1964), making it unlikely that they carried them to their nests. It is probable that only very young rabbits or portions of them were carried to nests. Porter and White (1973) noted that Prairie Falcons prey on White-faced Ibis (*Plegadis chihi*, 519 g) in Utah. However, since White-faced Ibis were

not found at Utah nests, they concluded that White-faced Ibis were too heavy for Prairie Falcons to carry. Adult Chukar (*Alectoris chukar*) and California Ground Squirrel (*Spermophilus beecheyi*) weigh between 500-565 g and were the next largest prey items found in eyrie samples and may have been brought to the nest by the female (863 g, Enderson 1964).

**Birds.** The Horned Lark and Mourning Dove were found in 63 and 42% of the nests, respectively. The presence of a Western Sandpiper (*Calidris mauri*) (Table 2) demonstrates the opportunistic hunting nature of Prairie Falcons. The Mojave River flows through the desert but is subterranean for much of its length. Sandpiper remains were found at a falcon nest 3.2 km from one of the few points where the river surfaces. The sandpiper was the only prey item not observed in the field.

**Reptiles.** Most Prairie Falcon food studies show that reptiles are infrequently reported as prey (Table 1); however, reptiles did constitute a relatively high proportion of the prey in this study (9.5%). Desert Horned Lizard (*Phrynosoma platyrhinos*) and Chuckwalla were found at 20% of the nests. Reptile remains, however, were recorded in only 4% of the pellets. Reptile scales were found mixed with mammal hair in castings but no castings contained both scales and feathers. It seems likely most reptile scales are so thin that they are digested and not cast. Usually, the only indication that reptiles were being used was the presence of heads and tails found around the margin of the nest. Although only lizards were represented in prey remains I did observe a male falcon leave its perch on a power pole and capture a snake.

**The 20% Rule.** Male falcons usually hunt for family groups during the nesting season (Newton 1979). Harmata et al. (1978) found that male Prairie Falcons hunted more frequently than females in the Mojave Desert. In this study 84% of prey captured weighed less than 150 g and the mean weight was 107 g, or 20% of the weight of male Prairie Falcons. A mean prey weight 20% of mean adult male falcon weight is also common in other species of falcons. I noted a high correlation ( $r = 0.98$ ) between mean prey weight during the breeding season and male falcon body weight for 5 species of falcons (Table 3). Because male falcons are restricted to a definite nesting territory during the breeding season, and are less restricted in movement during the remainder of the year, it seems



Table 3. Mean weight (g) of male falcons selected to show a weight range and the mean weight of their prey captured during the nesting season.

SPECIES	MALE WEIGHT	PREY WEIGHT ( $\bar{x}$ )	SOURCE
<i>Falco columbarius</i>	187	26	Laing 1984
<i>Falco eleonora</i>	350	62	Walter 1979
<i>Falco mexicanus</i>	554	143	This Study
<i>Falco peregrinus pealei</i>	750	199	White 1973
<i>Falco rusticolus</i>	1,170	475	Roseneau 1972

probable that characteristics of prey vulnerability and density (during the breeding season) have evolutionarily dictated male falcon size. To test this hypothesis one needs to compare weight of prey captured by females when they begin to hunt after brooding is completed with that caught by males. An alternative hypothesis is that selection pressure is highest during winter months and not during the breeding season. If this were true male and female falcons should show significant differences in the weight of prey captured during winter.

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# PERCHING AND ROOSTING PATTERNS OF RAPTORS ON POWER TRANSMISSION TOWERS IN SOUTHEAST IDAHO AND SOUTHWEST WYOMING

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**ABSTRACT**— As part of an ongoing raptor management program, 45 km of 345 kilovolt (kv) transmission lines were surveyed from 5 June to 31 September 1983 to determine diurnal and nocturnal raptor use patterns. The Golden Eagle (*Aquila chrysaetos*) and Red-tailed Hawk (*Buteo jamaicensis*) perched mostly on upper, outer sections of transmission towers during the day and roosted on lower, inner sections at night. Daytime surveys alone may not accurately represent raptor use of these structures.

In many treeless areas where availability of nest, perch and roost sites may limit raptor populations, electrical powerline structures are readily utilized by many raptor species (Stahlecker 1979; Olen-dorff et al. 1981). In recent years utility companies have become more aware that the raptor/powerline association is sometimes detrimental to both man and bird, and have initiated studies to examine raptor use of powerlines. The most commonly used technique is daytime aerial surveying (e.g., Wilder 1981; Hansen 1982). Relatively little information has been gathered concerning raptor roosting behavior on powerlines and how it may compare to perching behavior (Craig and Craig 1984). This

paper presents results of a study funded by Idaho Power Company in spring and summer of 1983 (Smith 1983), which was designed to collect information on nocturnal and diurnal behavior of raptors on electrical transmission towers in southeast Idaho and southwest Wyoming.

## STUDY AREA AND METHODS

The study area is located 30 km north of the convergence of the Idaho/Wyoming/Utah borders (Fig. 1). Three 345 kv transmission lines transmit electrical power through the study area from a coal-fired generating plant near Rock Springs, Wyoming to 3 separate substations bordering the Snake River plain in southern Idaho.

The 45 km study section is situated on the Idaho/Wyoming border and traverses mostly rolling, arid, treeless terrain 1800-2100 m in

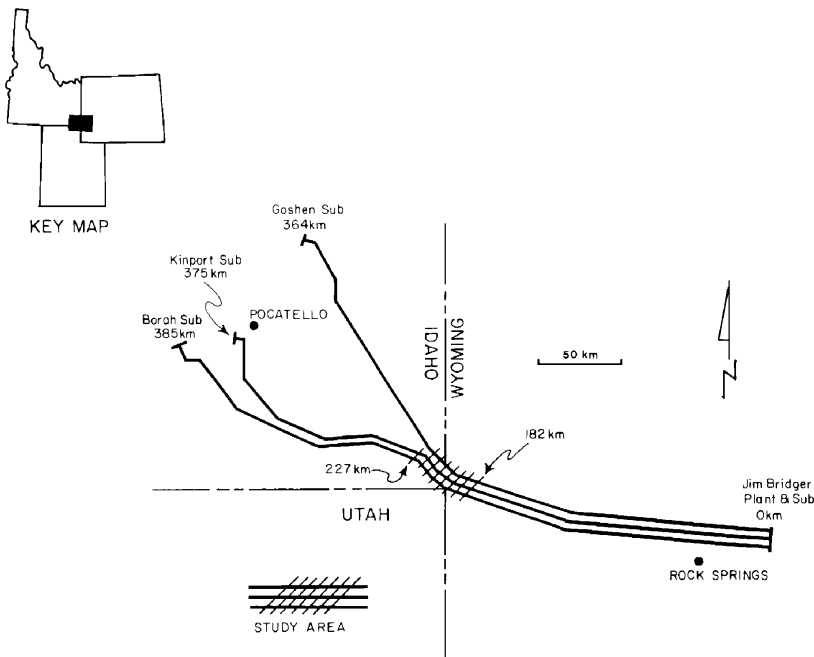


Figure 1. Transmission line route and study area.

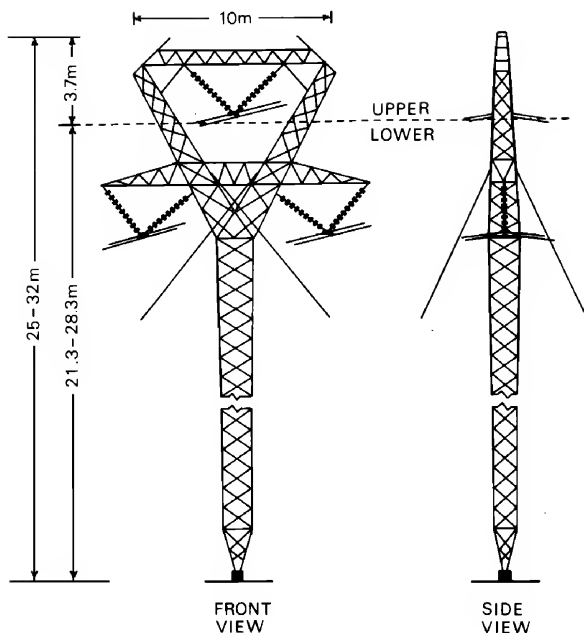


Figure 2. Configuration of 345kv transmission tower.

elevation. Three lines in the study area contain a total of 348 guyed aluminum towers, 25-32 m in height (Fig. 2). Dominant plant species for most of the area is big sagebrush (*Artemisia tridentata*).

Raptors most commonly sighted on towers were the Red-tailed Hawk (*Buteo jamaicensis*) and Golden Eagle (*Aquila chrysaetos*). During the post-fledging period (10 July to 31 September), an observed maximum of 28 fledgling and adult Red-tailed Hawks and 8 fledgling and adult Golden Eagles used the towers in this area for roost and/or perch sites. Seven Red-tailed Hawk nests and 2 Golden Eagle nests were the only occupied raptor nests present on transmission towers within the study area in 1983.

The study area was surveyed from a vehicle on 45 nights between 5 June and 31 September 1983. Surveys began at dusk and usually terminated 1-2 h before dawn. Each tower was examined using a hand-held spotlight and binoculars. The reflective property of the raptors' retinæ aided in locating birds at night. A light amplification device, or nightscope, was found to be unsuitable for this task due to inadequate magnification when used alone and poor resolution when used in conjunction with binoculars or spotting scope. Observations of birds at specific roost sites were made on 24 nights between 24 June and 9 September, to determine if movement to and from roost sites took place during the night. In all cases, Golden Eagles ( $n = 19$  nights at 14 locations) and Red-tailed Hawks ( $N = 5$  nights at 5 locations) did not move from their roost towers at any time during the night.

Lines were also surveyed from the ground on 15 d between 21 July and 31 September. Day surveys began at 0700 H and were completed by 1400 H.

Perching/roosting observations were classified according to time of day, species, and position on tower. "Inside" refers to any position on the tower that is surrounded on at least 4 sides by tower members (referring to the 6 sides of a cube). Upper/lower position

designation used in data analysis (Fig. 2) was chosen because very little perching/roosting occurred in the slanted portions of the towers (Red-tailed Hawks — less than 10% of all observations, Golden Eagles — zero observations). Birds were observed perched mainly in 2 regions of the transmission towers, the uppermost horizontal crossbridge area and the lower horizontal crossarm area (Fig. 2).

## RESULTS AND DISCUSSION

Most significant observed differences between diurnal and nocturnal use patterns were as follows:

1. Eagles and hawks showed a significant shift from using *outer* tower sections during the day to using *inner* tower sections at night.
2. Both species exhibited a shift from using *upper* sections of the towers during the day to using *lower* sections at night.

Data for Red-tailed Hawks consisted of 99 perch and 236 roost observations. Data for Golden Eagles consisted of 46 perch and 124 roost observations. Frequencies of observations in each category were used to generate 2x2 chi-square contingency tables to test the null hypothesis that time of day was independent of observed perch/roost location on the towers. Chi-square values (Fig. 3) indicate that

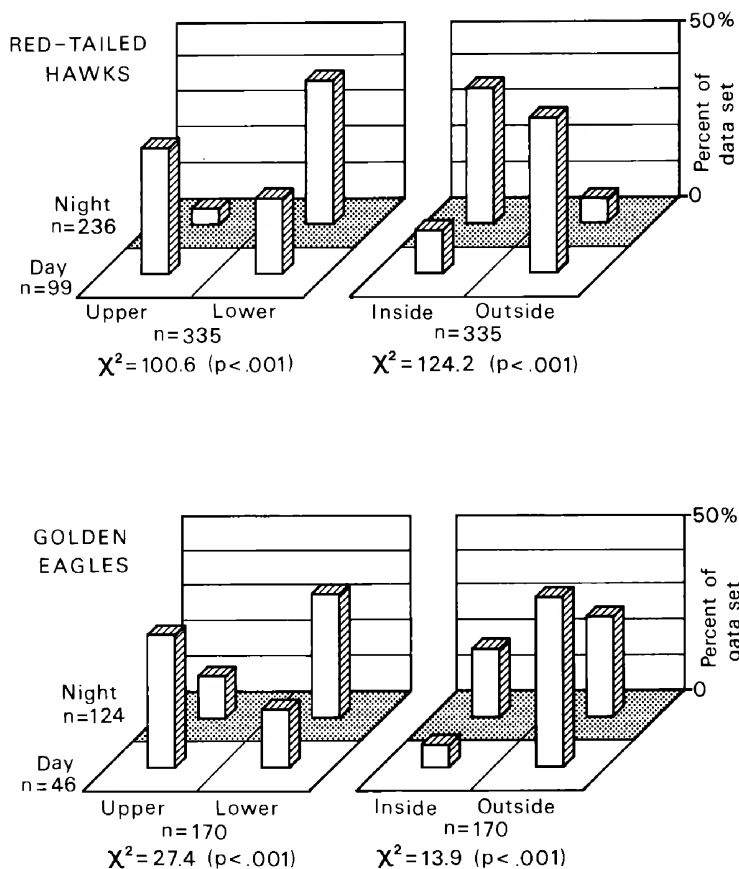


Figure 3. Relative frequencies of perch and roost observations on transmission towers in southeast Idaho and southwest Wyoming for the period 5 June to 31 September 1983. Chi-square ( $\chi^2$ ) values were generated from observed frequencies in each category. Day = 0700-1959 H. Night = 2000-0659 H.

diurnal use patterns differed significantly from nocturnal use patterns for both species. Results indicate that daytime surveys alone may not accurately represent overall use of towers as perch/roost structures, and should be supplemented by nocturnal observations.

Red-tailed Hawks exhibited larger day-outside/night-inside differences than did Golden Eagles ( $\chi^2 = 78.8$ ,  $P < 0.001$ ), possibly due to differences in body size and mobility. The hawks could land and take off directly from inner tower members, whereas eagles were required by girder spacing to walk and hop into and out of some inner locations.

Both Red-tailed Hawks and Golden Eagles ap-

peared to react behaviorally to transmission towers much as they do to natural substrates such as trees or cliffs. Upper, outer portions of the towers, used for diurnal hunting and resting perches, provided the advantages of an elevated viewpoint and unobstructed takeoff and landing flight paths. Lower, inner portions of the towers afforded what little cover there was in the area and were used for roost sites.

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# Relationship Between Prairie Falcon Nesting Phenology, Latitude and Elevation

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The relationship between timing of reproduction, latitude and elevation is a well known biological phenomenon: birds in northern areas breed later than birds in southern ones (Alee et al. 1949; Johnston 1954; Morton 1978). The Peregrine Falcon (*Falco peregrinus tundrius*) showed delayed nesting in North America with increasing latitude (White 1964). The Prairie Falcon (*Falco mexicanus*) in New Mexico (Platt 1974) and Oregon (Denton 1975) showed delayed nesting with increasing elevation. However, the cumulative effect of latitude and elevation on reproductive phenology has not been examined

for any of the large falcons. It would be of general interest to know to what extent the variation in timing of reproductive phenology can be influenced by latitude and elevation. Additionally, an analysis of this phenomenon may elucidate general trends and/or physical limitations that determine the breeding range of large falcons.

The Prairie Falcon presents an ideal study case for an examination of this phenomenon. It breeds over a wide range of latitudes, from 25.5° N (Lanning and Lawson 1977) to 54° N (Fyfe pers. comm.), and elevations, from near sea level (D. Boyce pers. comm.) to 3688 m (Marti

Table 1. Mean values for latitude and clutch completion date, sample size, and source study for 20 local populations of the Prairie Falcon.

°N LATITUDE	CLUTCH COMPLETION	BREEDING PAIRS	SOURCE
25.5	23 March	5	Lanning and Lawson 1977
32	10 March	1	Mader pers. comm.
32.5	29 March	1	Porter pers. comm.
34.2	9	1	Porter pers. comm.
35	26 March	24	Boyce pers. comm.
37	14 April	15	Platt 1974
40	13 April	10	Porter and White 1973
40.5	25 April	36	Enderson 1964
40.5	17 April	17	Olendorff 1973
41	17 April	9	Craig pers. comm.
41	3 May	23	Williams 1980
42.5	13 April	68	Ogden and Hornocker 1977
43	12 April	5	Johnstone 1980
44.5	16 April	49	Denton 1975
45.5	27 April	66	Becker and Ball 1981
47	6 April	6	Monk 1981
48	28 April	38	Leedy 1972
51	3 May	7	Edwards 1968
52.5	26 April	17	Fyfe pers. comm.
54	10 May	1	Fyfe pers. comm.
GROUP (X ± S.D.)			
43.1° ± 4.5°	18 April ± 10d	n = 401	

Table 2. Mean values for elevation and clutch completion date, sample size, and source study for 20 local populations of the Prairie Falcon.

ELEVATION (m)	CLUTCH COMPLETION	BREEDING PAIRS	SOURCE
700	6 April	8	Monk 1981
700	13 April	68	Ogden and Hornocker 1977
700	26 April	17	Fyfe pers. comm.
700	10 May	1	Fyfe pers. comm.
1030	26 March	24	Boyce pers. comm.
1100	27 April	66	Becker 1981
1180	29 March	1	Porter pers. comm.
1200	10 March	1	Mader pers. comm.
1200	16 April	49	Denton 1975
1200	3 May	7	Edwards 1968
1500	12 April	5	Johnstone 1980
1500	13 April	10	Porter and White 1973
1500	28 April	38	Leedy 1972
1700	17 April	17	Olendorff 1973
1700	14 April	15	Platt 1974
1800	25 April	36	Enderson 1964
2000	17 April	9	Craig pers. comm.
2510	9 April	1	Porter pers. comm.
2720	3 May	23	Williams 1980
2800	23 March	5	Lanning and Lawson 1977
GROUP ( $\bar{X} \pm \text{S.D.}$ )			
1320 $\pm$ 540 m	18 April $\pm$ 10 d	N = 401	

and Braun 1977). However, observations of Prairie Falcons nesting at elevations greater than 3000 m are few and do not permit analysis of the effects of high elevation on nesting phenology. Nevertheless, the Prairie Falcon has been well-studied and data are available from local nesting populations for latitudes 25.5° - 54° N (Table 1) and elevations 700 - 2800 m (Table 2). Data from the source studies (Tables 1 and 2) were reported in highly varied forms, therefore it was not possible to calculate standard deviations or standard errors for many of the mean values listed. The sequential events in the reproductive phenology of large falcons (e.g., territory establishment, copulation, hatching and fledging) are difficult for the researcher to observe and to record accurately with regards to time. It is relatively easy, however, to age young nestlings in the eyrie (see Fowler 1931; Moritsch 1983) and establish hatch dates. Traditionally, clutch completion dates have been calculated by backdating 30 days from hatching dates (Olendorff 1973). I employed this method for studies listed in Tables 1 and 2, unless specific data or different methods were provided by individual authors. In this study, therefore, mean clutch completion dates

(Tables 1 and 2) were used as the data base for statistical analysis and were assumed to be representative of the timing of the Prairie Falcon's reproductive phenology in each locality reported.

On this basis, I tested the prediction that Prairie Falcons nest at higher elevations in southern latitudes and at lower elevations in northern latitudes by dividing the reported breeding range (25.5° - 54° N latitude, Table 1) into quartiles. Weighted mean elevations for the quartiles were compared using ANOVA (SAS 1982) with the southernmost quartile ( $\bar{x} \pm \text{s.d.} = 2340 \pm 786$  m) differing significantly ( $F = 10.5$ ,  $P < 0.0001$ ) from the 3 more northern quartiles. Although the mean elevation of the northernmost quartile ( $\bar{x} \pm \text{s.d.} = 1177 \pm 376$  m) was the lowest of the means, it did not differ significantly (Duncan's Multiple Range,  $P < 0.05$ ) from the central 2 quartiles (south-central  $\bar{x} \pm \text{s.d.} = 1344 \pm 567$  m).

Multiple regression techniques (SAS 1982) for linear and non-linear models were applied to the combined data from Tables 1 and 2. A linear model (clutch completion =  $5.361 + 2.036 \text{ latitude} + 0.012 \text{ elevation}$ ) provided the best fit ( $R = 0.85$ ,  $P < 0.001$ ) with latitude accounting for

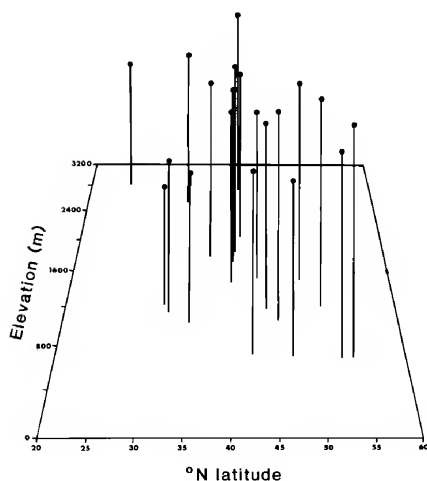


Figure 1. Clutch completion dates by latitude and elevation for 20 breeding populations of the Prairie Falcon. Clutch completion dates (range 10 March - 10 May) are depicted by circles atop vertical lines where height of line increases with increasing date. See Tables 1 and 2 for date.

64% of the variation in clutch completion dates and elevation an additional 21%. A general trend is observable in Figure 1 in which the mean elevation of nesting Prairie Falcon populations decrease with increasing latitude. The strong relationship of clutch completion date with latitude is easily seen in Table 1. Two studies (Lanning and Lawson 1977; Williams 1980) that do not appear to conform to the relationship had mean elevations greater than 2700 m (Table 2), which may have delayed clutch completion date.

The relationship of clutch completion date with elevation is not as apparent (Table 2). It is interesting to note that the 2 populations nesting north of 52° N latitude (Fyfe pers. comm.) (Table 1) both nested at 700 m (Table 2), the lowest nesting elevations considered in this study. Conversely, the southernmost population (25.5°N latitude (Table 1)) nested at 2800 m, the highest elevation considered in this study. It seems, therefore, that these patterns may represent the extremes of the Prairie Falcon's breeding range and nesting phenologies, with birds in the south using the cool mountain tops in Mexico (Lanning and Lawson 1977) and Canadian prairie birds utilizing escarpments along low-lying prairie river systems (Fyfe pers. comm.). In both situations, specific nesting localities may provide a climate more equitable for breeding Prairie Falcons than the prevailing climate at that latitude. Falcons in northern regions may be utilizing behavioral and ecological adaptations to augment their nesting attempts, such as choosing south and/or east facing eyries (see Williams 1984) rather than being restricted to nesting on low-elevation escarpments along river systems. Such diversity in nesting phenology could provide a means of range expansion or a means of utilizing a variety of habitats to accomplish reproduction.

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## Recapture of a Non-breeding Boreal Owl Two Years Later

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On 22 April 1984, while mist-netting owls at Whitefish Point, Chippewa County, Michigan, I recaptured a Boreal Owl (*Aegolius funereus*) that was banded at this location by Warren A. Lamb on 3 May 1982. There are no known summer or breeding records for this species in Michigan, though fair numbers are captured at Whitefish Point during most springs (Payne 1983). Thus, this bird was apparently moving north during both years it was captured following a southward movement during the preceding fall or winter.

Periodic southward movements of the Boreal Owl have received previous attention (Anweiler 1960; Bent 1961; Mysterud 1970; Catling 1972; Evans and Rosenfield 1977). However, to my knowledge this is the first time a Boreal Owl has been recaptured in North America in a subsequent year following a southward movement. Recapture in a subsequent year of owls banded during migration is not a common occurrence as shown by the low recapture rate of the highly migratory Northern Saw-whet Owl, *Aegolius acadicus* (Woodford 1959).

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## Fall Raptor Concentration on Henrys Lake Flats

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In the early 1970's we became aware of raptor concentrations of primarily *Buteo* spp. on Henrys Lake Flats in late summer and early fall. A concentration of large numbers of raptors on a high mountain meadow intrigued us, and from 1974 to 1983 we conducted annual roadside surveys to monitor raptor abundance and gain insight into why they were concentrating in this area.

Henrys Lake Flats is located between 1,950 and 2,000 m in

elevation in Fremont County in the northeast corner of Idaho. The flats extend from 1 to 8 km from Henrys Lake and are characterized by large, wet meadows and gently rolling plain dominated by big sagebrush (*Artemisia tridentata*). Most of this land is moderately grazed by cattle with at least a short grass/herb cover over practically all the land during the period of our surveys. The flats are surrounded by coniferous stands of primarily lodgepole

Table 1. Total raptor sightings on a 32 km automobile transect around Henrys Lake, Idaho, for the period 1974-1983. All transects conducted between 28 August and 4 September of each year.

SPECIES	YEAR										
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	MEAN
Red-tailed Hawk ( <i>Buteo jamaicensis</i> )	12	10	6	14	28	32	114	135	136	39	52.6
Ferruginous Hawk ( <i>Buteo regalis</i> )	46	28	16	7	16	48	67	21	34	31	31.4
Swainson's Hawk ( <i>Buteo swainsoni</i> )	11	12	3	3	4	15	34	17	19	14	13.2
Unidentified Buteo		2				3		4	1	9	1.9
Sub-total	69	52	25	24	48	98	215	177	190	93	99.1
Northern Harrier ( <i>Circus cyaneus</i> )	11	11	5	9	3	2	6	2	4	5	5.8
Sharp-shinned Hawk ( <i>Accipiter striatus</i> )	2	2	5	2	2		1			1	1.5
Cooper's Hawk ( <i>Accipiter cooperii</i> )				2			1		1		0.4
Goshawk ( <i>Accipiter gentilis</i> )			2			2					0.4
Osprey ( <i>Pandion haliaetus</i> )		5	2	2	2					8	1.2
Bald Eagle ( <i>Haliaeetus leucocephalus</i> )				1	1	3	2	1	2	2	1.2
Golden Eagle ( <i>Aquila chrysaetos</i> )		1	2		1		1		1		0.6
American Kestrel ( <i>Falco sparverius</i> )	33	12	8	9	5	9	5	4		9	9.4
Prairie Falcon ( <i>Falco mexicanus</i> )	2		2			3	4	3		1	1.5
Total	119	83	49	51	62	115	235	187	198	112	121.1

pine (*Pinus contorta*) extending down from surrounding mountains.

We drove a 32 km automobile transect route around Henrys Lake once annually in the last few days of August or first week of September. Heading north, the route started in Section 24, Range (R) 43 East (E), Township (T) 14 North (N) on a secondary road which parallels U.S. Highway 20/191. We detoured approx. 1.5 km onto the road to Henrys Lake State Park, where we parked and walked about 100 m north to a bluff and surveyed the surrounding area with a 30 X spotting scope. We returned to U.S. Highway 20/191 and continued north until turning west on U.S. Highway 287. We traveled on U.S. Highway 287 until turning south on a gravel road in Section 32, R 42 E, T 13 N, where we continued around the lake and reunited with U.S. Highway 20/191. The route traveled was mainly through open meadow or sage plain with the exception of the last few km before rejoining U.S. Highway 20/191. Using USGS quadrate maps, we estimated surveying about 68 km<sup>2</sup> of open country.

Surveys were conducted on calm, clear mornings and were generally completed before 1030 H. At least 2 competent observers conducted each survey. The transect route was traveled at speeds < 35 kph, and frequent stops were made at good vantage points or when raptors were sighted. Traffic was minimal on the route, except sometimes U.S. Highway 20/191 had moderate traffic.

An average of 121.1 raptors/yr were sighted for the 10-yr period (Table 1), of which 99.1 (83%) were buteos, resulting in 4 raptors sighted/km traveled. Sightings in 1974-75 were near the 10-yr average, but sightings in 1976-77 were low. Buteos were particularly low in 1976-77. A severe drought in 1976-77 resulted in a reduction in raptor productivity in the Birds of Prey Natural Area, near Boise, Idaho (Snake River Birds of Prey Environmental Statement, 1980, B.L.M., Boise, pp. 2-11), which corresponds with an ebb in our observations. Perhaps the build-up in subsequent years is a reflection of raptor recovery from the 1976-77 drought.

The Red-tailed Hawk (*Buteo jamaicensis*) was the most common raptor sighted, averaging 53 birds/survey (Table 1) with a range of 6 - 136 birds. Such a large range for sightings could reflect annual productivity in the region, since >90% of red-tail sightings were of birds in immature plumage. Adult red-tail sightings were confined to small meadows and clear-cuts surrounding the main flats. Adults may have limited themselves to peripheral areas to avoid harassment from immatures who often congregated around kills. Once we observed up to 11 immature red-tails fighting over a single prey.

The Ferruginous Hawk (*Buteo regalis*) was the next most frequently sighted raptor, averaging 31.4 birds/survey (Table 1) with a range of 7 - 67. Most Ferruginous Hawks sighted were also in immature plumage. Except for 2 birds perched on the edge of a clear-cut in 1983, all Ferruginous Hawks were sighted on the main flats. The observation bluff was a particularly good concentration spot, with less vegetation, allowing excellent views from ground level.

Ferruginous Hawks have been known to move to Henrys Lake Flats from the Raft River Valley along the Utah-Idaho border, about 250 km to the southeast (Thurow et al. 1980. Raptor Ecology of Raft River Valley, Idaho, E.G. and G., Inc., Idaho Falls, Idaho, and pers. obs.). In late summer food availability becomes limited in Raft River Valley since Black-tailed Jackrabbits (*Lepus californicus*) become less diurnal to avoid heat (Thurow et al. 1980). The Ferruginous Hawks apparently respond by drifting on pre-

vailing wind currents, which move primarily towards the Henrys Lake area.

The Swainson's Hawk (*Buteo swainsoni*) sightings averaged 13.2 birds/survey for the 10-yr period (Table 1) with a peak of 34 in 1980. Unidentified buteos and 9 other diurnal raptors sighted accounted for an average of 23.9 more sightings/survey.

The heavy concentration of raptors at Henrys Lake Flats is probably due to the abundance of Richardson's Ground Squirrels (*Spermophilus richardsoni*). Ground squirrels at lower elevations are known to estivate in late summer and fall, when hot, dry weather eliminates or drastically reduces succulent vegetation (Ingles, L.G. 1965. Mammals of the Pacific States. Stanford University Press, California). The high elevation of Henrys Lake Flats keeps vegetation green, and the ground squirrels are active and available as prey. There may be a general tendency for raptors to move up slope as ground squirrels estivate and rabbits become more nocturnal. We have observed similar concentrations of buteos in early fall from 2,000 to 3,000 m elevation on Steens Mountain in southeast Oregon, where Belding's Ground Squirrels (*Spermophilus beldingi*) were still active. In addition to an abundant food supply, the Henrys Lake area lies just west of the Continental Divide and may act as a corridor for migrating birds in general (Larrison, E. 1981. Birds of the Pacific Northwest: Washington, Oregon, Idaho and British Columbia. University Press of Idaho, Moscow).

Our automobile surveys indicate that high mountain meadows are important late summer concentration areas for buteos, especially those in immature plumage. The Henrys Lake Flats and other high meadows of the intermountain west have become increasingly popular recreation areas. Recreation and other forms of land use may affect high meadow ground squirrel populations, which in turn may affect raptor concentrations in those areas.

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## Bald Eagle (*Haliaeetus leucocephalus*) Consumption of Harbor Seal (*Phoca vitulina*) Placenta in Glacier Bay, Alaska

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This note reports on the frequent consumption of Harbor Seal (*Phoca vitulina*) placenta by the Bald Eagle (*Haliaeetus leucocephalus*) and a fluctuation in numbers of Bald Eagles in Muir Inlet, Alaska, in relation to the availability of this food source.

From 30 May to 23 August 1982 and 8 to 13 June 1984, we spent 41 d in our study area in the northern portion of Muir Inlet, located in the northeast corner of Glacier Bay in southeast Alaska. This recently (within the last 20 yr) deglaciated area is about 20 km long and an average of 2 km wide. The shoreline rises steeply on both sides of the inlet and consists of loose rock and glacial debris. There are no trees and vegetation is extremely sparse. Up to 1,000 Harbor Seals rest and give birth to young on small icebergs formed by an active tidewater glacier at the head of Muir Inlet. Our research was focused on the biology and behavior of Harbor Seals in this area. Our regular censuses and observations of seals required us to scan the entire inlet with binoculars and spotting scopes and consequently observe eagles and their interactions with seals.

On 9 occasions in early June, we observed Bald Eagles feeding on Harbor Seal placenta; these were the only times we saw eagles feeding in our study area. In one instance we saw 6 eagles either feeding on the placenta, chasing after an eagle with placenta, or perching near a feeding eagle. At each of 3 Bald Eagle perches visited in early June 1982, we found from 2 to 15 clumps of lanugo hair (the fetal coat of Harbor Seal pups that is shed before birth and is expelled with the placenta).

Bald Eagle numbers in our study area changed through the season and corresponded to the time of Harbor Seal pupping. We saw a minimum of 4-7 eagles on 5 d between 31 May to 17 June 1982 and a minimum of 5 on 2 d between 8 and 13 June 1984. We saw fewer eagles during visits later in the season. During the latter part of June we saw up to 2 eagles. In 16 d of observation in July and August 1982, we had only one eagle sighting. Bald Eagles in Muir Inlet consisted about equally of mature and immature birds, 4 of the 7 seen at one time in June 1982 and 3 of the 5 seen at one time in June 1984 were mature. The majority of Harbor Seal pups in Muir Inlet are born in late May and early June, the same period we saw the largest numbers of Bald Eagles. In both 1982 and 1984, over 300 Harbor Seal pups were born in this portion of Muir Inlet. Given a minimum weight of 1 kg for a Harbor Seal placenta, this would mean an excess of 300 kg of food available to eagles.

We concluded that Bald Eagles in this area during late May and early June subsist largely or entirely on placenta of Harbor Seals because: 1) our frequent observations of eagles feeding on placenta and not on other food, 2) the abundance of this food source and the scarcity of other food sources in this deglaciated area, 3) the presence of seal lanugo hair found at eagle perches, and 4) the close parallel between the number of eagles in our study area and the Harbor Seal pupping season. Eagles appear to use this area for only a short period; we found no evidence of eagle nesting.

Sherrod et al. (Living Bird 15:143-182, 1976) reported that Bald Eagles on Amchitka Island, Alaska consume northern Sea Lion (*Eumetopias jubatus*) afterbirth. It is the only other report we know that mentions Bald Eagles feeding on placenta of pinnipeds. We have observed Bald Eagles feeding on seal placenta and

scavenging on dead seal pups in other parts of Glacier Bay and Puget Sound, Washington.

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## Barred Owl Hunting Insects

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Although the Barred Owl (*Strix varia*) is partially insectivorous (Bent, U.S. Natl. Mus. Bull. 170, 1938) its methods of hunting and capturing insects have not been described. From 1924-2000 H we observed a Barred Owl hunting insects on 4 April 1984 at Blue Springs Stake Park, Orange City, Florida. The Barred Owl was apparently hunting noctuid moths (Lepidoptera) and large veined insects on the lawn of an historic house in the park. The owl hunted these insects from a small stump or on a sandy stretch of lawn beneath a lighted area. In hunting, the owl sat motionless except for slight head movements to watch the insects. Captures were attempted only after the insects landed. Capture attempts were a combination of 3 movements: 1) a bound initiated from a partially forward leaning position, 2) a single wing flap and 3) a short glide. Attempts covered 1-2 m distances and the owl was twice observed to follow missed attempts with 2 or 3 immediate additional pounces. Insects were captured with the talons and consumed by bringing the head down to pick the insect from the talons. One insect not immediately consumed was transferred to the beak before the owl flew to a nearby tree. At 1949 H the Barred Owl returned to its hunting perch on the lawn where it unsuccessfully attempted two more captures before leaving the area at 2000 H. During the time observed, the Barred Owl was successful in 2 of 18 capture attempts.

Forsman et al., (Wildl. Monogr 87, 1984) reported that the Spotted Owl (*Strix occidentalis*) diet also includes insects and that these owls used pounces to capture insects on the ground or on tree limbs. Also, mid-air captures of flying insects were not observed.

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## Northern Harrier Predation on Greater Prairie Chickens in Southwest Missouri

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Although habitat preferences of the Northern Harrier (*Circus cyaneus*) and the Greater Prairie Chicken (*Tympanuchus cupido*) are quite similar (Berger et al. 1963), harriers are rarely reported to prey upon these galliformes (Yeatter 1943; Schwartz 1945; Grange 1948; Weller et al. 1955; Ammann 1957; Berger et al. 1963). Other similar-sized avian prey such as Ring-necked Pheasant (*Phasianus colchicus*), Sharp-tailed Grouse (*T. phasianellus*), American Bittern (*Botaurus lentiginosus*), ducks and the Domestic Chicken (*Gallus* spp.) are, however, not infrequently taken (Fisher 1893; Peabody 1900; Errington and Breckenridge 1936; Bent 1937; Brown and Amadon 1968) although usually as juveniles (Peabody *op. cit.*; Saunders 1913; Randall 1940; Hecht 1951).

This note reports predation on adult and young Greater Prairie Chickens in the tall-grass prairie region of southwest Missouri during spring and summer 1984. The study area of 850 ha consisted of Prairie State Park and surrounding private lands. Prairie State Park is 1 mi southwest of Liberal, Missouri, in Barton County. Vegetation consists of bluestem grasses (*Andropogon* spp.), Indian grass (*Sorghastrum nutans*) and other native grasses and

forbs, as well as invading cool season grasses such as fescue (*Festuca* sp.). Old and reclaimed strip mines and deciduous woody growth are scattered throughout the area. Neighboring lands are mostly crops and fescue (Larson 1982).

A total of 325 h were spent observing harriers and prairie chickens from 7 April - 7 August 1984. Using techniques described by Hamerstrom (1969), I found 7 harrier nests (density of 1 pair/121 ha) clumped in 3 loose aggregations in undisturbed grasslands.

Approximately 150 prairie chickens were concentrated around 4 booming grounds on the study area during early spring (April-May) and later scattered throughout the area during nesting (May-July). At least 2 prairie chicken nests were located within 200 m of 2 harrier nests.

Visits to Northern Harrier nests during the nestling stage were made to collect prey remains and/or pellets. I calculated frequency of occurrence of prey types from fresh pellets and identified prey remains. Percent composition of each prey species was calculated from the number of each type divided by the total. Percent biomass was estimated by weights given in Schwartz and Schwartz (1959), Terres (1980) and Steenhof (1983).

Analysis of food items revealed a catholic diet (Table 1). The diet of nesting Northern Harriers in other regions has been of a similar euryphagus composition (Randal *op. cit.*; Hecht *op. cit.*, Craighead and Craighead 1956; Brown and Amadon 1968; Smith

Table 1. Prey of nesting Northern Harriers at Prairie State Park in southwest Missouri, 1984.

PREY	FREQUENCY OF OCCURRENCE	% COMPOSITION	AVERAGE WEIGHT (G)	ESTIMATED % BIOMASS
<b>BIRDS</b>				
Greater Prairie Chicken ( <i>Tympanuchus cupido</i> )	8	6.6	624	22.6
Adults	3		908	12.3
Juveniles	5		454	10.3
Mourning Dove ( <i>Zenaida macroura</i> )	3	2.5	134	1.8
Eastern Meadowlark ( <i>Sturnella magna</i> )	6	4.9	95	2.6
Common Grackle ( <i>Quiscalus quiscula</i> )	2	1.6	112	1.0
Red-winged Blackbird ( <i>Agelaius phoeniceus</i> )	6	4.9	50	1.4
Brown-headed Cowbird ( <i>Molothrus ater</i> )	3	2.5	41	0.5
Unidentified passerines	11	9.0	75	3.7
Total birds (Table 1 continued)	39	32.0		33.6

(Continuation of Table 1)

## MAMMALS

Prairie vole ( <i>Microtus ochrogaster</i> )	24	20.0	8	4.1
Fulvous harvest mouse ( <i>Reithrodontomys fulvescens</i> )	6	4.9	21	0.5
Deer Mouse ( <i>Peromyscus maniculatus</i> )	2	1.6	20	0.2
Cotton rat ( <i>Sigmodon hispidus</i> )	1	0.8	120	0.5
Eastern wood rat ( <i>Neotoma floridana</i> )	1	0.8	255	1.2
Unidentified rodents	7	5.8	30	0.9
Eastern cottontail ( <i>Sylvilagus floridanus</i> )	9	7.4	1200	49.0
Total mammals	50	41.3		56.4

## REPTILES

Plains garter snake ( <i>Thamnophis radix</i> )	1	0.8	109	0.5
Unidentified snakes	11	9.1	190	9.5
Total reptiles	12	9.9		10.0

## INSECTS

Coleopterans	12	9.9	0.5	tr <sup>1</sup>
Orthopterans	8	6.6	1	tr
Total insects	20	16.5		tr

TOTAL PREY ITEMS	121	100.0		100.0
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<sup>1</sup>tr = trace.

and Murphy 1973; Snyder and Wiley 1976). A total of 7 prairie chicken remains were collected from the 2 harrier nests closest to prairie chicken nests. Of these 7 remains, 5 represented half-grown juveniles and 2 represented adults.

An eighth prairie chicken was captured by an adult female harrier on 25 July at 0700 H. The hawk hovered briefly 4 m above a dense stand of bluestem grasses and fescue, before diving into the vegetation. After waiting about 10 min, I approached the site and the hawk flushed when I was about 20 m away. I discovered a dead adult female prairie chicken that was partly depuffed and still warm. I was unable to find a prairie chicken nest in the immediate vicinity, but numerous droppings and matted vegetation (form) indicated that the prairie chicken had been on its roost. I left the site and watched from a distance of ca 300 m until the

harrier returned to her kill after nearly 20 min. Berger et al. (1963) observed prairie chickens being captured by raptors (including 1 female Northern Harrier) early in the morning. Campbell (1950) reported an unsuccessful capture attempt of a Lesser Prairie Chicken (*T. pallidicinctus*) during evening hours. Poor light during early morning and late evening hours may make approaching raptors more difficult for prairie chickens (or other quarry) to spot (Berger et al. 1963).

All prairie chicken prey was brought to harrier nests during the last half of the nestling stage. During this time female harriers spent as much time hunting for their young as did males. It is probable that the larger females (50% heavier than adult males) caught the adult prairie chickens (Berger et al. 1963). I observed several adult male harriers feeding on mammalian prey among



displaying prairie chickens at booming grounds just prior to the nesting season. The prairie chickens seemed oblivious of these male harriers. Female harriers, however, usually evoked a response from prairie chickens, ranging from a brief squat to an all out flush. Berger et al. (1963) reported that over a 4-year sample of harrier-prairie chicken reactions, prairie chickens flushed nearly 70% of the times female harriers approached, but only 30% of the times males approached. Of the 33 times that prairie chickens completely ignored approaching harriers, 94% were male hawks and 6% were females. Female Hen Harriers (*C. c. cyaneus*) take significantly more Red Grouse (*Lagopus lagopus*) and other gamebirds than do males (Marquiss 1980).

I have found no evidence of Northern Harriers preying on Greater Prairie Chickens during winter or on booming grounds in early spring. However, prairie chickens did comprise a significant proportion of Northern Harrier diets (22.6% biomass; Table 1) during the nesting season when female and juvenile prairie chickens in close proximity to harrier nests may be more vulnerable to raptor predation.

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**The Migration of Birds of Prey in the Northern Red Sea Area: Report of the 1982 Suez Study** by David Wimpfheimer, Bertel Bruun, Sherif M. Bahael Din and Michael C. Jennings with contributions by William S. Clark, Carsten Jensen, Donald Parr and Ib Petersen, and forward by Dean Amadon. Arabic summary by Assad Serhal. 80 pp., 6 Tables, 24 Figures, 2 Appendices, 10 plates. Available from the Holy Land Conservation Fund, 1825 Eye Street Northwest, Suite 400, Washington, DC 20006. \$20.00 U.S.

Whenever the nation of Egypt is mentioned, thoughts come to mind of the pharaohs, the great pyramids and the sphinx. One also remembers Egypt's biblical and more recent history, both closely tied to the nation of Israel. Thoughts of migrating raptors do not immediately come to mind. Yet this report has made it apparent that a spring migration of raptors does occur over the lands of Egypt, and undoubtedly has done so since before the great pyramids were built.

The report describes the initial results of the Holy Land Conservation Fund's expedition to Suez, Egypt, in the spring of 1982. As a result of many individual efforts and outstanding support from numerous individuals and agencies, both in the United States and Egypt, the authors have provided students of raptor migration with a data base for reference and future comparison for the Middle East. All of the authors except one have previous experience with Eurasian raptors. Observational data are reported for 124,996 raptors, representing 28 species, sighted during the period 23 February - 16 May 1982. The primary goal of the study was to learn more about the spring migration of raptors at or near Suez, Egypt, and towards that goal the authors have a good start. However, there is some question as to whether the report effectively establishes the Suez area as a concentration point as stated. Certainly there is a substantial spring overfly in the region, but the evidence supports the idea that raptors do not initiate migrations in the immediate vicinity of the city of Suez, and thus do not concentrate themselves in the area.

A species by species account of sightings by time period and a seasonal total is provided for each of the 28 species tallied. Comparisons by species are made with other regions, particularly Eliat, Israel. Six species, *Buteo b. vulpinus*, *Aquila nipalensis*, *A. pomarina*, *Milvus migrans*, *Circus gallicus* and *Neophron percnopterus* accounted for 90% of total sightings. Sightings of *B. b. vulpinus* alone accounted for almost 65% of total numbers, but the *vulpinus* tally is biased by the inclusion of all *B. buteo* sightings with the *vulpinus* totals, as pointed out by the authors. Less than 10 individuals were tallied for 12 species. Observational data for 214 non-raptors are provided in Appendix A, which includes 3 new sightings for Egypt. Histograms of related species are provided depicting total numbers versus date. The figures could have been combined in many cases, especially Figures 14 and 15 and Figures 17 and 18. Analysis by 5-day interval would have been most helpful and welcome, but such was provided only for accipiters, which represented 0.2% of total sightings.

At least 2 observers were present on most days, and there was a gap in continuous coverage during early April when no observations were made. In order to compensate for these gaps, the authors extrapolated data for observations both before and after periods of no coverage. On this basis, adjustments were calculated for selected species, including *Aquila* sp., *A. pomarina* and *A. nipalensis*. Adjustments were made with the assumption that the proportions of identified *Aquila* is the same as unidentified, which is confusing. However, these adjustment figures do not appear in final tallies and conclusions. Virtually every individual raptor sighted was identified at least to genus, and no "unidentified" category appears in the final tallies. As one who has observed North American migrations over the years, it is simply not possible to always pinpoint an individual, though worthy a goal such identification may represent.

Intermittent observations made in areas adjacent to Suez were also accomplished. Brief summaries are provided for Hurghada and surrounding area, for northern Sinai between El Arish and Nakhl, for Ismalia north of Suez (all observations accomplished by one or more of the authors), and summaries of previous reports in the literature for the region and for Eliat, Israel. Previous reports and more recent studies indicate the migration at Eliat is substantially greater than reported for Suez and surrounding areas (W.S. Clark, pers. comm.). Also included is a chapter on raptor migration in the Middle East which provides the reader with a nice comparison as well as a substantial reference list.

As the authors point out, their attempts to correlate meteorological factors with their observations needs further study. Purely qualitative evaluations of wind direction, wind strength(?) (only for surface winds), and cloud cover are provided with species tallies. Qualitative assessment carries over into observations, where individuals are grouped under the heading of being either an "active" or "passive" migrant based upon convection current utilization (Table 6) (after studies of raptor migration in Denmark by B. Bruun and O. Schelde, 1957, *Efteraarstrækker pa Stignæs, S.V. Sjaelland, D.O.F.T.* 51:149-167). The usefulness of such categorization seems questionable, since any individual of any species may either actively or passively utilize convection currents at any given time.

Appendix B summarizes human threats to migrating raptors. Although there is little evidence of direct persecution such as shooting (Plate 4 of a "hunter" displaying 2 recently shot Steppe Eagles notwithstanding), potential for harm from chemical dumping and industrial pollution does exist in the Suez area. No mass kills have been reported, but as with most chemical contaminants, raptors that feed, bathe, or drink while enroute through the region probably pick up harmful compounds which would be transported back to breeding territories.

Overall, the report provides valuable data to the ever-growing worldwide raptor migration picture. Sherif Ben el Din's illustrations evidence a keen familiarity with migrant raptors enroute through Suez. A more comprehensive assessment of observations would have been a welcome addition. Nevertheless, an 82-item literature section is provided which helps to substantiate the report as a basis for comparison with future raptor migration studies in the Middle East. — Jimmie R. Parrish.

**ERRATUM** — Volume 18(4), page 159. Paul Springler should be Paul Springer. The Editorial Staff apologizes to Paul for failing to catch the misspelling before final printing.

## ANNOUNCEMENT

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**Proceedings of the Southeastern United States and Caribbean Osprey Symposium** — published by The International Osprey Foundation, Inc., edited by Mark A. Westall. Eleven papers, 132 pages. Copies can be ordered from The International Osprey Foundation, Inc., P.O. Box 250, Sanibel, FL 33957 USA. Price: \$16.00 U.S.

**The Southwestern Raptor Management Symposium and Workshop** will be held on the University of Arizona Campus, Tucson, 22-25 May, 1986. The Symposium will focus on raptors in the southwestern United States and adjacent Mexico. Sessions will cover raptor biology, management and research techniques, impact mitigation, and population status. There will also be a workshop on research and management priorities. For more information, or if you are interested in presenting a paper, contact Brian A. Millsap, Raptor Information Center, Institute for Wildlife Research, National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036.

**Bird Banding by Elliott McClure**, The Boxwood Press, Pacific Grove, California. 341 pp., 5½ x 8½, paper: **\$15.00.** — While this is a general book on bird banding there are several sections concerning raptors. McClure spent a large portion of his active professional life in Southeast Asia and much of the material is drawn from his experiences there. There are 13 distinct sections varying from the geological background of migration routes (the example is from Southeast Asia), nets and snares, banding nestlings, to the art of record keeping. There are 35 index entries for birds of prey (11 of those are for owls). Under the section, "The Bird and its Banding Idiosyncrasies," there is a page and a half devoted to owls and 2 pages to falconiforms. Most of the standard trapping methods used on hawks are discussed (many variations of the Bal-chatri). An interesting method of snaring the buzzard (*Buteo*) is discussed at some length. This book has some valuable tips for raptor banders and it is well worth looking at. — C.M. White.

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